PRODUCT ENGINEERING

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Shout It From the Housetops

DURING the past decade, the layman's knowledge of science and industry has rapidly increased. Editors of popular magazines and newspaper supplements have reported a tremendous growth of reader interest in scientific subjects. Millions who visited the Century of Progress Fair at Chicago were impressed by the wonders of science and industry, and made acquainted with the latest technical developments. Advertisements in popular magazines expound the virtues and qualities of materials and standard machine parts, emphasizing points of superiority, thus building up public acceptance.

Turning to the other side of this picture, product engineers struggle unceasingly to incorporate in their designs the highest quality parts and units and materials compatible with price. Many hours of planning, numberless tentative designs and experiments often go into a single improvement. To create a higher quality product at little or no extra cost is not an accomplishment to be ignored.

But in spite of the evident appreciation of even the lay public for the merits of certain materials, types of construction, and quality unit parts, in spite of the user acceptance for such things that has been built up by expensive national advertising programs, and in spite of the earmarks of quality that engineering refinements might proclaim, the advertising literature of many fine products often fails to mention such things or buries the quality engineering specifications in a maze of superlative adjectives.

Some advertising writers claim that the public is not interested in materials or parts used, that the prospective purchaser is wholly interested in the results obtained. This philosophy would have been tenable twenty years ago. But it ignores the great strides in education of the public, presupposes a complete failure of "user acceptance" advertising and assumes that the age of skepticism has not arrived.

Advertisements are admittedly not the place for laborious descriptions of engineering details. But when a manufacturer offers a new product, uses new units and materials of recognized and superior quality, when his engineers have by ingenious scheming created a superior construction, he should let the world know about it. Automobile advertisements feature such things. Some manufacturers in other fields do likewise. But as a whole, the advertisements of new products, particularly consumer goods, are woefully lacking in this respect. In their advertisements manufacturers should capitalize the merits of engineering skill, and the accomplishments of their engineering departments should be shouted from the housetops.

Professional Development

AFTER two years of quiet but intensive study, a committee on professional development, made up of representatives of the four founder engineering societies, the S.P.E.E. and the National Council of State Boards of Engineering Examiners, has brought in a report that is of fundamental interest to every engineer. We give the high spots of the report on pages 432 and 433.

Division of professional development into four stages: student selection and guidance, undergraduate education, training during the first few years after graduation, and professional recognition, of the successful engineer, represents a rounded approach to the problem that is without precedent in engineering experience. One of the noteworthy things about the project is the unanimous agreement of the council members on a program that represents such a radical departure from the present hit-or-miss efforts.

Acceptance of the committee report implies an entirely new conception of engineering society membership. The old requirements, loose enough in at least two of the founder societies, were loosely interpreted as well. Under the new definitions full membership will have a significance entirely different from that which exists today. And the change will be all for the better.

Aims, Results and Trends
in Product Development

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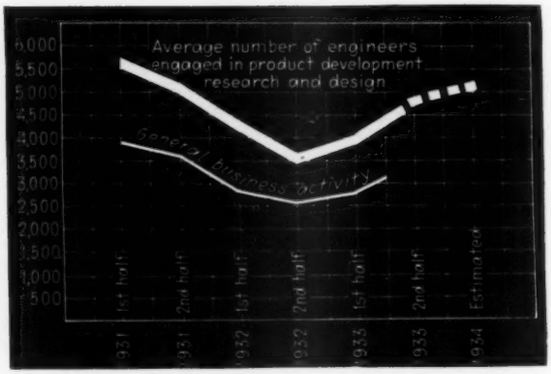
As Revealed by a Nation-Wide Survey of Current Activity



The curve of the number of engineers employed in product design closely parallels the curve of the business index

IN THIS second annual survey of product development conclusive evidence points to greatly increased activities in all fields. The most direct evidence is the number of men actively engaged in design, research and product development. Combining the figures of the 1932 survey and those obtained in the present survey, using the overlapping periods for adjusting the figures, the accompanying curve of number of men employed in product development was constructed.

One of the significant features of this curve is its close agreement with the curve of the index of business activity which is based on the weekly index of general business activity compiled by *The Business Week*. Although it is to be expected that these two curves should show a definite relationship, the significant fact is that they run almost exactly parallel. There is no lag between the return of business and the pick-up in engineering activity.

Products of the metal-working and allied industries can be divided into two main groups, capital goods and consumer goods. In the former group belongs all the machinery and equipment used for construction, manufacturing and doing business, while in the latter class are all those products used in every-day life. Each of these two main divisions has its own characteristic aims.

In the capital goods industries the fundamental aim is, of course, to increase the earning power of the machinery or equipment. With reference to this it is interesting to observe the relative importance of various design aims. This is primarily a reflection of the recognition of the service value of the improvements by the user of the product. From year to year, as new developments arise and conditions change, the market value of certain design features also changes. Thus we now see a tremendous swing in the field of railroad and railway equipment towards light-weight construction, vibration dampening, streamlining, air-conditioning and greater passenger comfort. Fierce competition has increased for the railroads the dollar value of such high-quality engineering design features.

Among the machine tool manufacturers there is an evident trend to improved electric controls, built-in motors and controls, and the application of hydraulic operation. The fundamental aim apparently is to increase the flexibility and speed of control and the compactness of the machinery. In construction machinery there is apparently an increasing tendency toward units having a wider range of use through the means of attachments. Although this feature is most pronounced in road maintenance machinery, it is now also finding more application to equipment that is primarily for general construction work, such as power shovels.

With reference to materials of construction, the worth of high-quality materials is evidently receiving greater recognition. As discussed in detail in this report, "stainless" steel heads the list of materials that are receiving the attention of product engineers. Next in order come aluminum and aluminum alloys, alloy cast iron, alloy steels and rubber.

Among the parts and units of construction, antifriction bearings lead the list of recent and expected adoptions of new parts and units, with electric motor drives, V-belts, self-lubricating bearings, electric controls, gun-type lubrication, flexible couplings, speed reducers, pumps and controls for hydraulic operation, clutches, variable-speed transmissions, roller and silent chain drives following in the order given.

In themselves, the above statements concerning new materials and parts being adopted have little significance as to the relative merits of the different items. But there is much significance in the fact that quality materials and parts that were considered too expensive to use only a decade ago are now, even on the heels of this depression, considered indispensable and are rapidly finding many new applications. It is a reflection of the increasing general recognition of quality value.

With reference to recently adopted and expected adoptions of different types of construction, welding heads the list. This is to be expected because of the many different fields in which this type of construction finds application. But in the fields of light machinery, household equipment and the like, rolled, drawn or extruded shapes, molded plastics and die-castings are apparently receiving the greatest attention of the product engineer.

Conclusions concerning design trends cannot be drawn to apply equally to all fields but are set forth in the various divisions to which they pertain.

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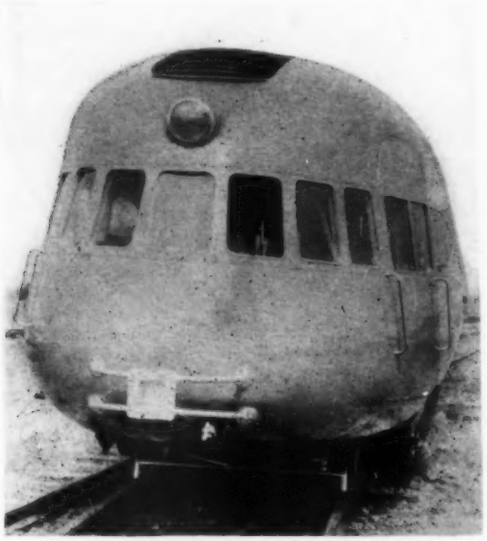
Transportation Equipment Leads in New Developments

Aluminum, alloy steels, rubber, improved power units and new types of design contribute to radical improvements in rail and air transportation



Streamlined light-weight coach built by Pullman. Framing is welded chrome molybdenum steel tubing, covered with duralumin sheets

TRENDS in railway motive power were strikingly summarized by William C. Dickerman, president of the American Locomotive Company, in an address entitled "Modern Trends in Railway Motive Power," before the New York Railroad Club. Excerpts from this address, of particular interest to all designing engineers because they reflect the attitude of a whole field of industry, follow:

"The value of research in American industry is unchallenged. Real progress is secured from untiring application in the direction of new fields of invention, discovery and development.

"I cannot believe that we have reached the point where we should slacken in our efforts to improve the machines we now have. In times like these, lack of actual construction might seem to indicate a cessation of activities along sound and advanced engineering lines. On the contrary, we have had the time, which we do not always have under normal conditions, for constructive thought and research. We shall, in the course of time, see definite progress as a result of this intensified consideration."

Indeed the most advanced design of steam locomotive was completed this year by the American Locomotive Company. Designed by John E. Muhlfeld, consulting engineer for the Delaware & Hudson Railroad, the locomotive has a water-tube firebox, operates at 500 lb. pressure, has four cylinders, two at the front and two at the rear end, all driving on one main axle. One of the rear end cylinders is high pressure, the other is intermediate, and the two cylinders at the front end are low pressure. Poppet valves are used. It is the first triple expansion poppet-valve locomotive in the history of American railroading.

The illustration on the following page shows the proposed design by the American Locomotive Company of a streamlined steam locomotive and train for heavy fast passenger service. According to Mr. Dickerman, this illustration indicates what we may look forward to in the near future. It would be capable of speeds of 90 m.p.h. or more, its parts would be extremely light and easily cared for and maintenance cost would be low.

The artist's drawing of this fully streamlined steam train is not a myth. A fundamentally quite similar

design using an oil-electric engine is now being built. In May of this year was announced the order placed by the Union Pacific Railroad for the construction of a light-weight, three-car articulated passenger train, wholly streamlined and capable of speeds up to 110 m.p.h., to be built by the Pullman Car & Manufacturing Corporation, and the Winton Engine Company. The principal features of this train are that the design closely follows automotive and aircraft practice, aluminum alloys are used wherever possible, complete streamlining has been adopted, the cars are air-conditioned with sealed windows and an extensive use is made of rubber to reduce noise and procure smooth running.

Another similar unit but using "stainless" steel for the principal material of construction is being built by the E. G. Budd Manufacturing Company for the Chicago, Burlington & Quincy Railroad. This car also is to be capable of speeds in excess of 100 m.p.h., with running speed of 90 m.p.h., and will also be powered by Winton oil engines direct-connected to generators. (See P.E., Sept. 1933, for details of these engines.)

Light-weight rail-cars have also been greatly advanced in design during the past year. The Edward G. Budd Manufacturing Company has been continuing the development of stainless steel self-propelled rail-cars built by the Shotweld process of spotwelding. The second Budd-Micheline rail-car uses a stainless-steel truck construction for the truck side frames as against the carbon steel truck frames used on the first car. A few other details have also been changed, but in the main the remainder of the construction is substantially along the same lines as the first of these cars which was described in detail in the April, 1932 number of *Product Engineering*.

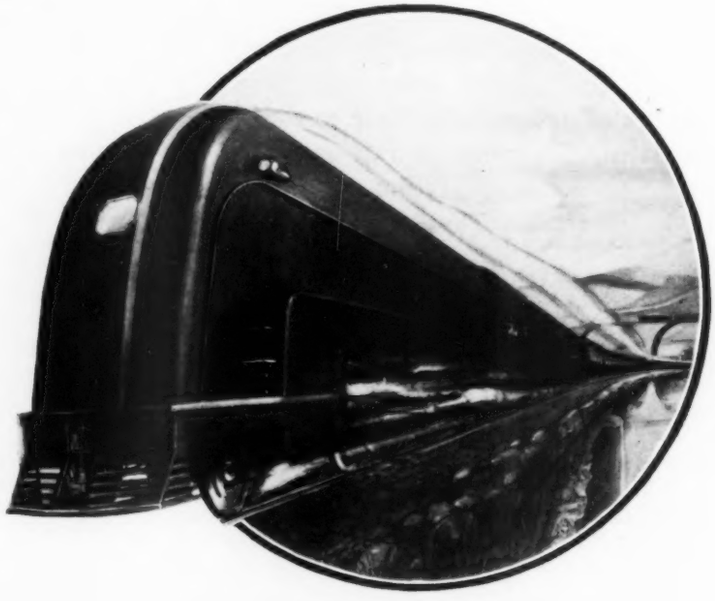
During the past year the Pullman Car & Manufacturing Corporation also built two all-aluminum cars which were exhibited at the Century of Progress Exposition. Both of these cars are intended for main-line passenger train service and they incorporate all of the refinements of air-conditioning, sealed windows and noise-elimination.

In the field of rail-car development, the Clark Autotram was described in detail in the October 1933 number of *Product Engineering* with reference to its use of rubber. It is representative of developments and trends in this field.

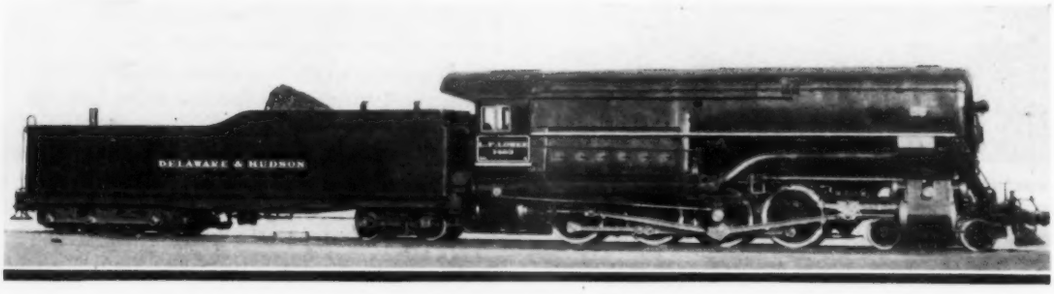
The latest light-weight rail-car finished this year is that designed jointly by the Stout Engineering Laboratories, Inc., and the Pullman Car & Manufacturing Corporation. This car, just completed, has full streamlining and is designed for maximum operating speeds of about 90 m.p.h. One of its features is the welded tubular steel construction for both the body and the truck frames, while the outside sheathing is of aluminum alloy sheets. Chrome-molybdenum steel is used for the tubing, and the parts are joined by welding.

Aircraft Designers Aim for Greater Passenger Comfort

Rapid development in the field of rail transportation has apparently spurred aeronautical engineers in making corresponding improvements in their field, or vice versa. Paralleling the increased speed in rail transportation, airplanes have reached a speed of 423 m.p.h. Passenger carrying capacity has been greatly increased, and developments are definitely toward more passenger comfort. This last is summed up in a statement by

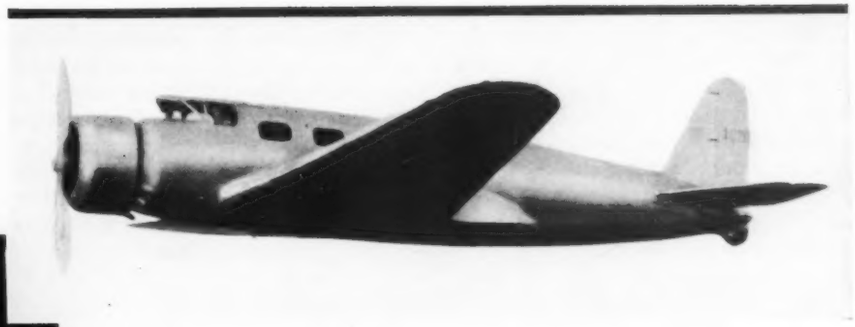


Streamlined steam locomotive and train for heavy fast passenger service, a proposed design by the American Locomotive Company



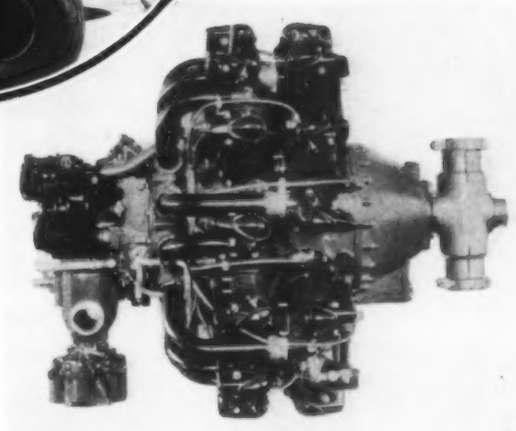
Designed by John E. Muhlfeld, this D & H triple-expansion locomotive built by the American Locomotive Company has poppet-type valves, high-pressure and intermediate-pressure cylinders at the rear, and two low-pressure cylinders at the front

Transport plane designed by Gerard Vultee and built by the Airplane Development Corporation exemplifies the recent trend to retractable landing gear and low-wing monoplane construction



New Curtis-Wright Condor twin-engine transports have retractable undercarriage, insulated cabin and the latest aerodynamic features

In designing the high and spacious air-conditioned cabins of the new Boeing transport planes, passenger comfort was given first consideration. Conversation can be carried on as easily as in a Pullman coach



Pratt & Whitney and Wright twin-row radials represent the trend toward more compact engines

Stephen J. Zand, engineer of the Sperry Gyroscope Company, under whose direction was developed the sound-insulated design of cabin for the Douglas "Airliners" built recently for Transcontinental & Western Air, Inc. According to Mr. Zand:

"This trend is well illustrated by the fact that the latest designs allow as much as 12 to 16 lb. of sound-insulating material per passenger, whereas 2 or 3 lb. was the maximum acceptable allowance only a few years ago. But the amount of insulation applied is not a measure of the efficiency of noise isolation. For example, until recently sound absorbing materials were applied without reference to the predominant noise frequency of the particular airplane. But, relatively little acoustical energy is required to produce unpleasant sensations upon the human ear in the lower frequency ranges from about 30 to say 300 cycles per sec., which unfortunately are predominant in most airplanes. Yet in this low frequency range, the usual sound absorbing materials have but little effect. Perhaps the greatest advance in sound isolation during the past year has been the development of a special type of selective sound absorption construction that is effective throughout a specific range of sound frequencies.

"As applied to the Douglas plane the duraluminum monocoque fuselage was first treated with a layer of felted Kapok cemented to the panels with a special rubber compound. This construction eliminates the excitation of the fuselage structure, a source of high frequency vibration. The inside of the cabin is covered with a washable fire-resisting fabric, with a special felt applied behind the fabric. By stretching the fabric envelope, it can be tuned to the predominant frequency of the airplane. This design absorbs 75 to 85 per cent at 256 cycles, and weighs only 0.2 to 0.25 lb. per sq.ft. This sound absorption system has been the main factor in lowering the sound to a level of 70 decibels above 1 millibar, with a frequency distribution such that passengers do not experience unpleasant effects, even after many hours in the air.

"The ultimate has not yet been reached in soundproofing, ventilating and heating of airplane cabins. With the sound level reduced to 60 decibels, airplane cabins will be sufficiently quiet for passengers to sleep in comfort."

Of the airplane manufacturers included in this survey, 85 per cent of them stated that one of the general

trends in their product development activity was to reduce manufacturing cost through interchangeable parts and unit construction. It is reflected in the Douglas "Airliners" in the detachable and interchangeable right and left engine mounts, the demountable outer wing panel and the removable cowling, gasoline tank covers and inspection plates. In the Seversky all-metal amphibian developed this year, the major part of the ship can be produced as unit assemblies by automatic machinery and then assembled into the ship. Such developments are primarily for the purpose of making possible assembly line production as in the automobile industry.

With reference to parts and materials of construction, 85 per cent of the companies covered in this report have recently or contemplate a further adoption of ball or roller bearings, rolled, drawn, or extruded shapes, lacquer finishes and electroplating. Additional applications of anti-friction bearings have reference to the equipment of controls, anti-friction engine crankshaft bearings and anti-friction bearings for rocker arms.

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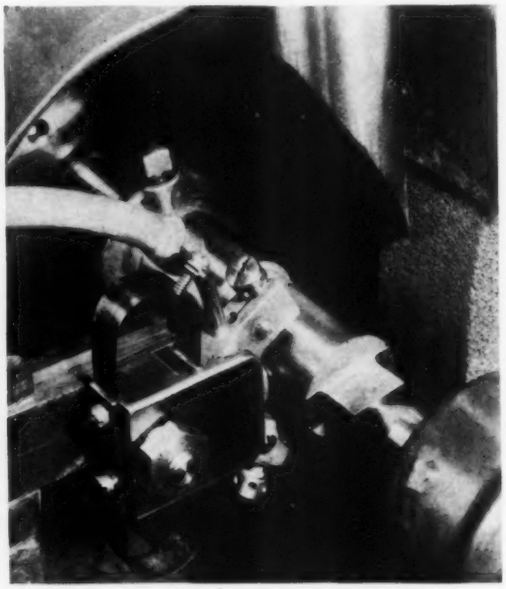
New Production Machinery Makes Old Equipment Obsolete

Alloy cast iron and steels, welded construction, hydraulic operation, built-in electric motors and controls, anti-friction bearings and improved lubrication used to create greater machine earning power



Automatic sizing device of the Landis Tool Company which provides an accuracy within 0.00025 in. Air jet orifice approaches finished surface, air line pressure increases and moves mercury column which closes electric solenoid circuits

THROUGHOUT all the capital goods industries there is evident the common aim of developing such fundamentally improved designs so that existing machinery will rapidly become obsolete. The different fields vary with reference to the character of the improvements by which it is expected to antiquate existing equipment, but in each instance, the fundamental idea is to increase the earning power of the machine to such an extent that the continued use of old equipment becomes extremely unprofitable.

Portable electric grinder of the Chicago Wheel & Manufacturing Company has cast aluminum motor housing, dust-sealed bearings, and universal motor

Machine Tool and Steel Mill Machinery

In the accompanying chart is shown how 31 of the leading manufacturers of machine shop and steel mill machinery directed their efforts in the development of improved designs. A breakdown of this chart according to the various kinds of machines would merely serve to emphasize the differences in the types of problems that characterize the specific kinds of machines. Thus, quite naturally, all of the manufacturers of milling and grinding machines put special emphasis on devices and materials to reduce vibration. Better electrical controls and accessories is the aim of 80 per cent of the reported manufacturers of milling machines. Similarly, automatic screw machines, lathes, and steel mill machinery have each their characteristic problems.

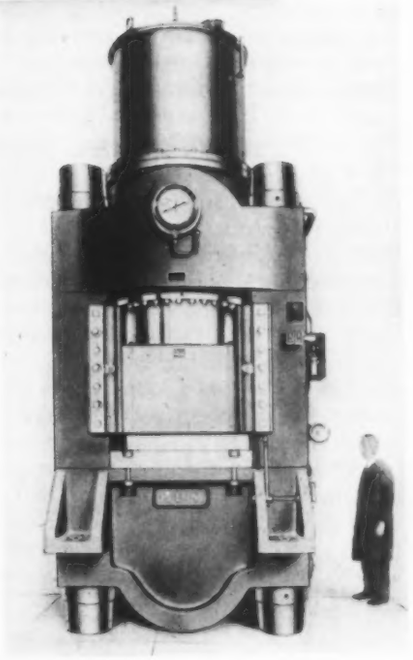
Concerning items that do not appear on the chart, it is significant that 62 per cent of the manufacturers reported changes primarily for the purpose of improvthe appearance of their product. One engineer representing a manufacturer of special machinery, states:

"I may say in general that of late the tendency in design is to improve the appearance of the machine by eliminating all possible bosses, projections, etc., and using ball or roller bearings and inclosed gears running in oil. In our own company we are making greater use of the worm gear type of drive."

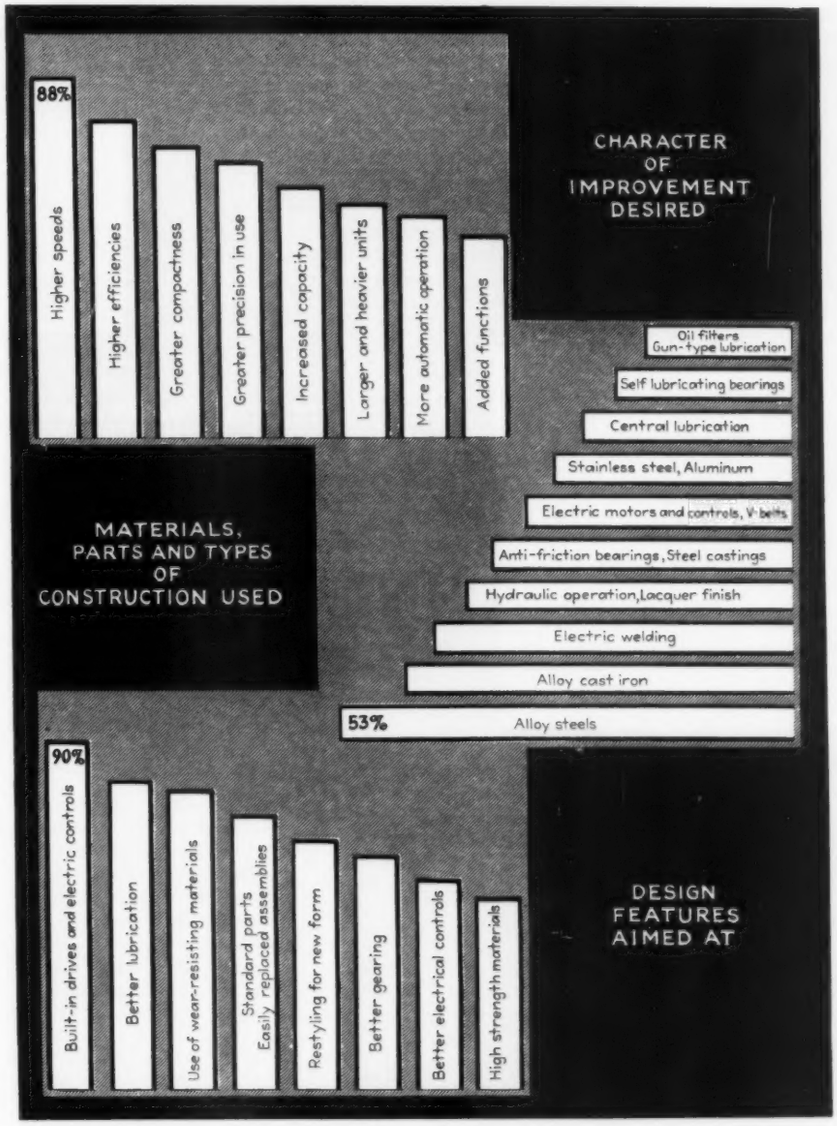
That appearance is receiving considerable attention is attested by the fact that lacquer finish ranks with pumps and controls for hydraulic operation when considering the materials whose adoption is being contemplated or that have been adopted recently.

The following items, although not mentioned as receiving particular attention from designers of machine tools and not included in the chart are prominently mentioned by the designers of mill machinery. Taken in the order, recently adopted or expected adoption of various parts and units include: short-center flat-belt drives, V-belt drives, clutches, flexible couplings, speed reducers, variable speed transmission, roller chains, silent chains, flexible shafting and universal joints. These recent adoptions indicate the trend of equipping heavy machines as self-powered units.

Although some of the leading machine tool manufacturers have been using lacquer on their machines for a



(Above) Black & Decker use pack hardened low carbon alloy steel spindles for their heavy-duty sander for wear resistance and high torsional stresses. (Below) Self-contained press with direct electric motor driven pump built by the Hydraulic Press Manufacturing Company. Hydraulic controls include automatic adjustable pressure regulation, variable strokes and die-shut height



The chart to the left shows how twenty-nine manufacturers of machine tools and steels mill machinery have improved their products

number of years, this survey reveals that there has been recently a definite trend toward a more general adoption of this type of finish. Apparently the old method of putting on a few coats of "shop paint" is no longer in general favor.

As might be expected, the interest in hydraulic control and operation of machine tools continues unabated. Three manufacturers of machine tools expressed themselves as expecting to adopt hydraulic operation in the near future. In the field of heavy machinery, three manufacturers have recently adopted electric heating units, primarily for plastic molding presses.

As to type of construction, the continued heavy trend toward welding is not surprising, it merely reflects the new possibilities that have been uncovered in recent years in the advancement of this art. Welded frames are now found in all types of machine tools. Perhaps the most striking developments of the past year were the rolling mill designed with rolled steel housings, the plate steel shears and brakes (*P.E.* March, 1933) and a planer with welded steel base.

On account of the condition of the market, many manufacturers are withholding their new designs awaiting improvement in business conditions. The forthcoming year will perhaps witness some startling new developments in this field of design.

Textile and Other Machinery

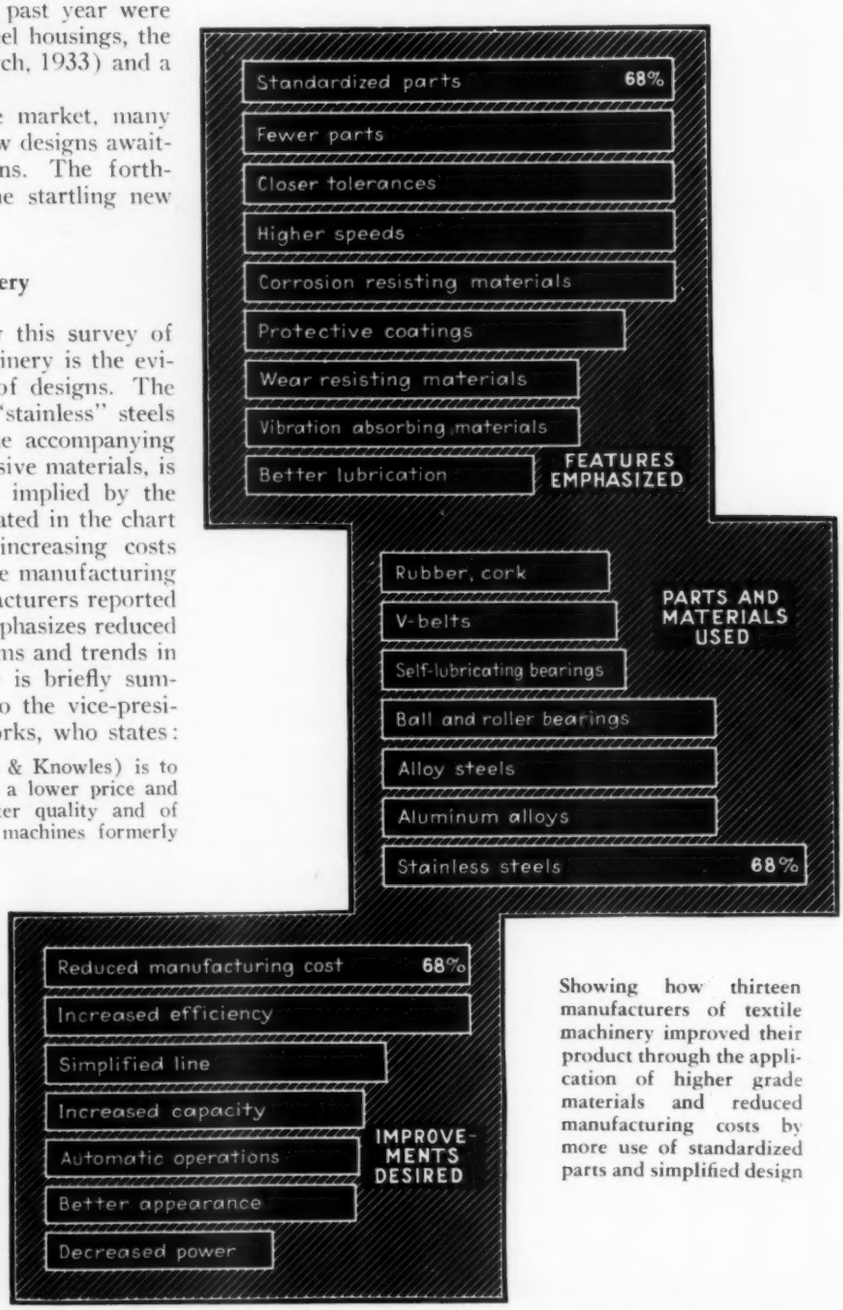
The most striking thing revealed by this survey of thirteen manufacturers of textile machinery is the evident trend toward greater refinement of designs. The many recent adoptions of alloy steel, "stainless" steels and aluminum alloys, as shown on the accompanying chart, all of which are relatively expensive materials, is significant. Such higher quality as is implied by the use of the parts and materials as indicated in the chart cannot be obtained without greatly increasing costs unless the design is simplified to reduce manufacturing costs. And 73 per cent of these manufacturers reported a product development program that emphasizes reduced costs of manufacturing. The special aims and trends in the improvement of textile machinery is briefly summarized by Albert Palmer, assistant to the vice-president, Crompton & Knowles Loom Works, who states:

"The object of the work here (Crompton & Knowles) is to produce better machinery which will sell at a lower price and that is capable of producing cloth of better quality and of greater variety than could be made on the machines formerly manufactured by us. The endeavor has been to simplify the design of the looms to permit machining by tools such as grinders, drills and lathes. Standardization has been effected in order that through mass production, machine plates and molding machinery can be used in the foundry, and in order that jigs, fixtures and special machine tools can be used in the shop. Through this equipment, interchangeability of parts has been brought about and the manufacturing cost has been reduced. Simultaneously the quality of the product has been improved in many ways.

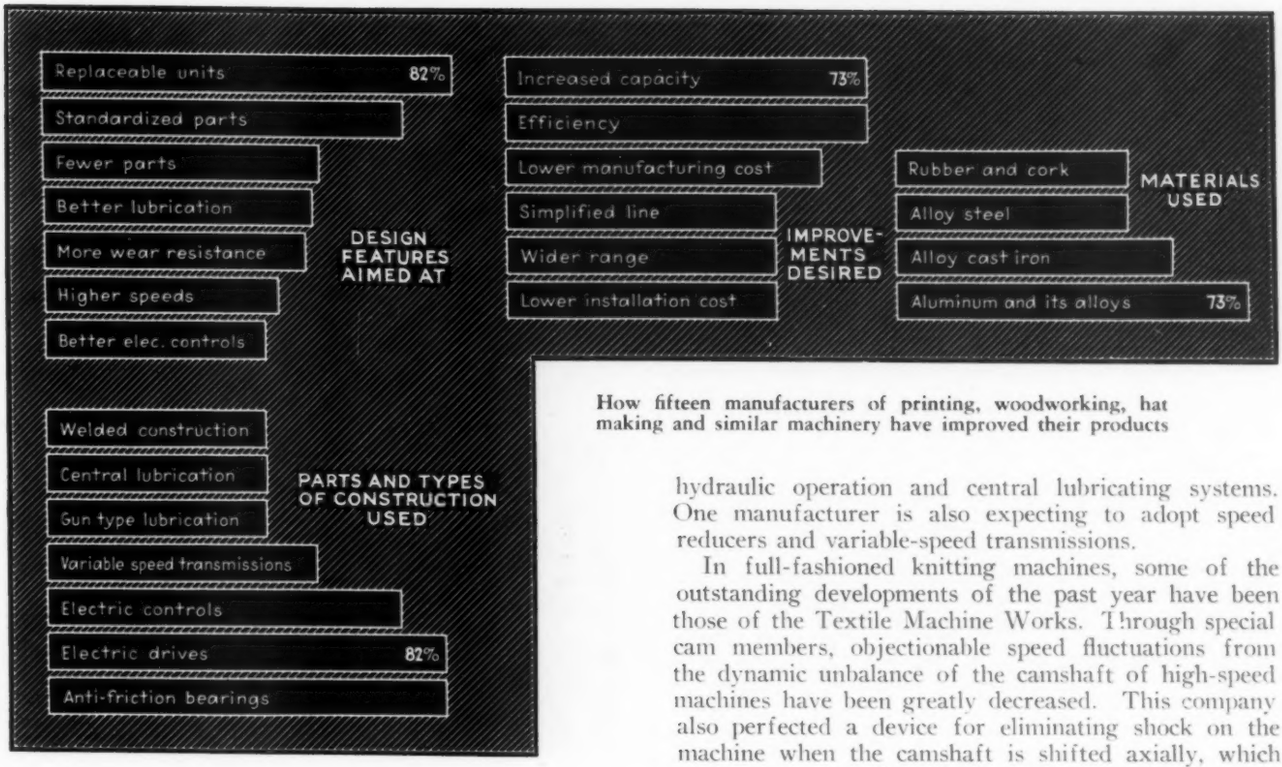
"Our customers have been benefited by this program of development because our product is much more flexible than it was formerly. By addition of suitable attachments our new looms can be changed from one type of fabric manufacture to another without the extensive rebuilding as in the past. In addition to this advantage, the new machinery has demonstrated its ability to operate more efficiently and at a higher speed than the old machinery and with lower maintenance cost. Also, the quality of the fabric is better than that of fabric produced on the old equipment."

A comparison of the results obtained from the survey this year with those reported in *Product Engineering* last year shows how the trends as then reported have extended in the direction of a higher refinement of the product. In this respect, manufacturers of textile machinery illustrate the trend of the capital goods industries in the improvement of their products.

The chart on the opposite page gives the relative importance attached to design aims by fifteen manufacturers of printing, woodworking and foundry equipment. Perhaps the most striking feature is the number



Showing how thirteen manufacturers of textile machinery improved their product through the application of higher grade materials and reduced manufacturing costs by more use of standardized parts and simplified design



How fifteen manufacturers of printing, woodworking, hat making and similar machinery have improved their products

of companies that have recently adopted parts and units that contribute to improved operation of their machines. Not indicated on the chart is the fact that two manufacturers of woodworking machinery are contemplating the adoption of pumps and controls for hydraulic operation and central lubricating systems. One manufacturer is also expecting to adopt speed reducers and variable-speed transmissions.

In full-fashioned knitting machines, some of the outstanding developments of the past year have been those of the Textile Machine Works. Through special cam members, objectionable speed fluctuations from the dynamic unbalance of the camshaft of high-speed machines have been greatly decreased. This company also perfected a device for eliminating shock on the machine when the camshaft is shifted axially, which device was described in June *Product Engineering*, p. 226. Other developments of this company are a device for positively stopping rotation of the draw-off reels in case the fabric is suddenly released from the needles for any cause whatsoever, and a slip coupling for overload release.

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Construction Machinery

Increased capacity and higher operating speeds focus attention on alloy steels and anti-friction bearings. Welding being used more generally

FUNDAMENTAL aim of designers of construction equipment are summed up by A. C. Rasmussen, chief engineer of the Insley Manufacturing Company, in the terse statement:

"Our present-day effort, as well as that of everyone else, is to endeavor to design the maximum amount of dependability into the product, as it is the dependability of a product that assures repeat orders."

Mr. Rasmussen gives an example of the results of such endeavors in the design of the Insley-Hercules power wheel scoop illustrated on the following page.

In modernizing of this new Insley scoop, the main problem was to create a construction having the strength to withstand the draw-bar pull of a modern large size tractor, to stand up under abusive handling of a careless driver, and even remain substantially undamaged should the scoop roll down a hill sideways, turning over and over. The design as finally developed has a tubular section cast steel frame for the larger size unit and an all-welded tubular frame for the smaller size, the tubular construction being for the purpose of obtaining maximum strength and rigidity with a minimum weight. This type of construction is also used for the axle arch.

To reduce draw-bar effort, tapered roller bearings are used for the wheels. The lift springs are of extra large size, made of silicon-vanadium high carbon spring steel. To control all of the scoops in a train, a rope from the operating platform on the leading scoop leads to internal-expanding-friction clutches in the wheels.

Concerning the use of high-strength materials, Mr. Rasmussen states:

"To give the most and best for the money calls for simple, light but dependable designs at the lowest overall cost. This does not require the use of high-strength materials throughout, but it does require that these materials be used wherever the

For strength and lightness, cast steel tubular sections are used for the frame and axle arch of the Insley scoops

Keystone Driller Company power shovel designed to use trench scoop, plunger bucket, demolition hammer or clamshell without changing boom

stresses are high or the service is severe. Unnecessary weight consumes power, but weak construction causes untimely breakdowns. Intelligent buyers expect uninterrupted service."

New developments by the Universal Road Machinery Company include a sand, gravel and chip spreader, a new traveling type crushing unit on a two-wheel roller bearing trailer truck with universal joint shaft and V-belt drive connection to the tractor power take-off. This company has also developed a new portable crusher fitted with four roller bearing wheels and with V-belt drive, and a new style air separator head fitted with anti-friction bearings. Their new street sweeper has rubber-tired, roller bearing wheels and uses a novel design for mounting the rear wheels. These are carried on stub axles which permits the rotary broom to be hung diagonally across the unit in the space usually occupied by the rear axle. The broom is driven off the rear wheels through a bevel gear and roller chain drive.

One of the striking developments in power shovels is the new unit developed by the Keystone Driller Company, Lynn H. Ranson, chief engineer. Previously, in changing utilities on a convertible power shovel it was necessary to change the boom. But in this new design a plunger bucket for general excavation above grade, a trench scoop for digging ditches, trenches and similar below-grade excavation, a 3,000-lb. demolition hammer for breaking pavements, rocks and frozen ground, and a clamshell bucket can be used interchangeably without removing the boom.

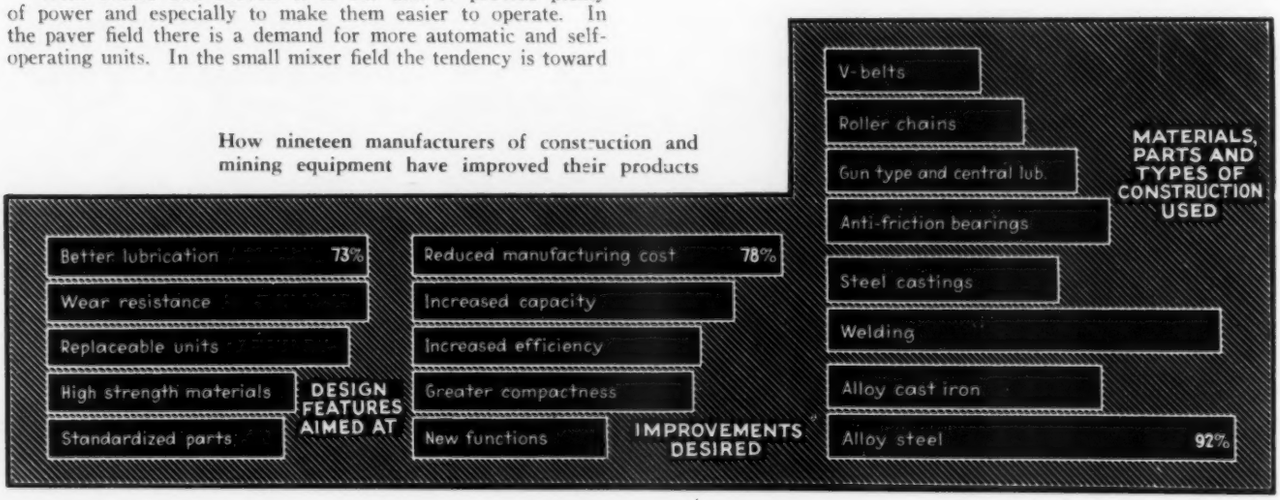
With further reference to product improvement aims, E. H. Lichtenberg, chief engineer of the National Equipment Corporation, states:

"With cranes and shovels it is our aim to provide plenty of power and especially to make them easier to operate. In the paver field there is a demand for more automatic and self-operating units. In the small mixer field the tendency is toward lightness and larger output. In earth hauling equipment the tendency is toward a specialized unit that can stand abuse and is especially designed for its purpose."

This company has developed what they call a Mud-jack for raising curbs, sidewalks, or concrete slabs. In the design of this little machine considerable use was made of high-strength materials in order to keep down the weight so as not to interfere with portability.

In the new portable loader of the Joy Manufacturing Company, E. Arentzen, chief engineer, a modified Allis-Chalmers industrial tractor unit equipped with semi-steel crawlers is used for the power unit. A special power take-off placed between the tractor engine and tractor clutch permits the conveyor and gathering arms to be driven continuously, the traction being used

How nineteen manufacturers of construction and mining equipment have improved their products

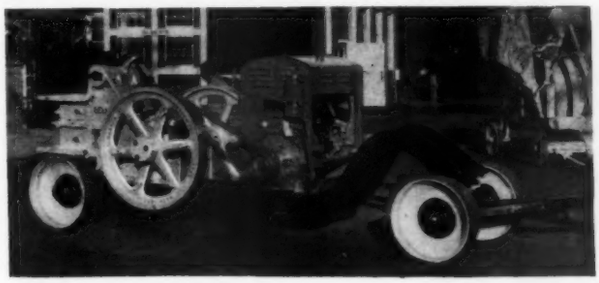


intermittently as needed for feeding the machine into the material.

E. J. Wilson, chief engineer and designer of the new line of Thew shovels, developed a center drive the principal advantage of which is increased mechanical efficiency through a more direct path of power transmission from motor to power shaft. A silent chain drive transmits the power to the center drive pinion, which gear powers the main shafts directly.

A second and perhaps equally important advantage of the center drive principle, according to Mr. Wilson, lies in the fact that this simplified design permits a considerable weight reduction and a more compact unit. Further weight reduction is attained through the use of heat-treated alloy steels and welded construction, and a tubular dipper stick.

Portable crusher of Universal Road Machinery Company is mounted on an I-beam truck with roller bearing wheels



Although not a piece of construction equipment, the recently developed garden tractor of the S. L. Allen Company, of Philadelphia, is a noteworthy example of high-quality engineering. As described by E. R. Glenn of their engineering department, the 3-hp. gasoline driving engine has ball bearing crankshaft and camshaft with a 6:1 speed reduction built into the motor. The chain-drive sprockets are hardened. A multiple dry-disk type clutch is used, with an oilless bearing for the pilot bearing in the clutch. Axles of the traction wheels are high tensile steel, ground and polished. The bronze bushed wheel hubs are grease lubricated, while sealed ball bearings with Alemite fittings are used on the clutch shaft. The frame and handles of the tractor are 0.50 carbon steel, while the castings are malleable iron and Meehanite.

Great flexibility is available in the arrangement of twenty different attachments for one, two or three row cultivation, and wheels are readily adjustable to 14, 16, 18 and 20½-in. centers.

▼ ▼ ▼

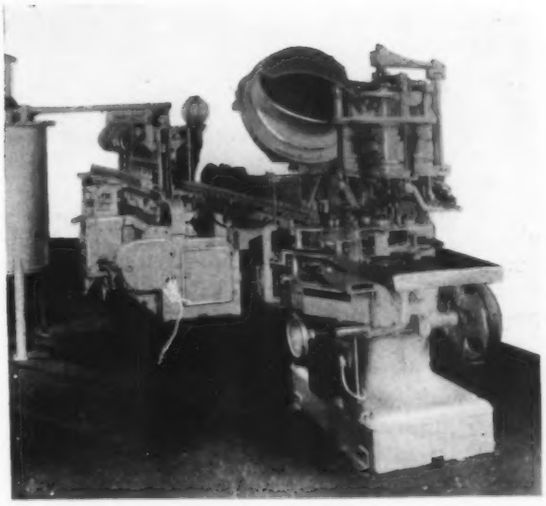
Food Machinery Extends Use of Stainless Steel

Improvements continue toward greater corrosion resistance and increased efficiency through better controls and drives

PRODUCTS of the 61 manufacturers represented in this group comprise all kinds of filters, coolers, food handling and processing machinery, dairy equipment, and filling, weighing and automatic packaging machinery. The outstanding feature in the recent developments common to all of these manufacturers is the strong trend toward stainless steel, aluminum or its alloys, and welded construction. In addition to these three items, designers in this group of products are primarily emphasizing more automatic operation for the purpose of increased output.

The chart on the next page shows the relative importance attached by the designers of this class of products to various design features. The universal aim for improved electrical control and accessories and the trend to built-in drives and controls, as indicated in the chart, is a reflection of the aim for greater compactness and improved operating features.

In the design of packaging machinery, new styles of packages and package innovations play an important part. This is strikingly illustrated by the comments of E. Lovell Smith, chief engineer of the Package Machinery Company, who states:



Bottles are vacuum cleaned, filled and capped in this automatic bottling machine developed by the Pneumatic Scale Corporation

"One of the most significant developments that has affected the design of automatic packaging machinery is the addition

to the package of some device that will make it easier to open. The use of cellophane and other cellulose material for the final wrapper makes a package more attractive and keeps the goods fresh from maker to user. This practice, however, tends to make the package harder to get into, and the next step is to add some easy-opening device.

"Examples of such easy-opening devices are the tab on Lucky Strike cigarettes and the red ribbon on Wrigley's gum, the tab on Beechnut gum, and the tape inserted in American Chicle gum so that one operation tears off both wrappers.

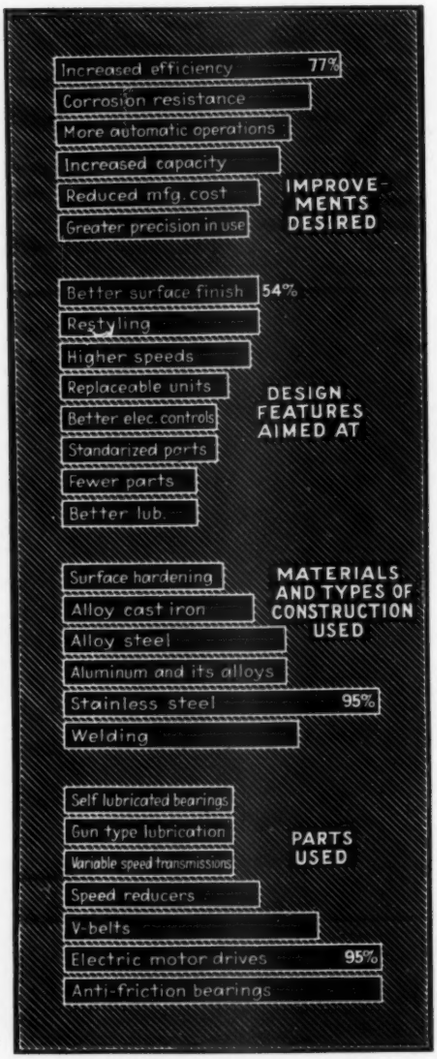
"Another trend is toward the adoption of labels printed in roll form. This has been made possible by the development of machines that can cut off the labels in correct register relative to the package. Such control has been greatly simplified and made speedier and more accurate by the application of photoelectric cells. Many examples of packages wrapped from cellophane rolls are now on the market, among them Loose-Wiles' 'Sunshine' biscuits, American Chicle's 'Tempters,' and the wrapper of Beeman's gum.

"A considerable part of the packaging machinery engineering departments is now engaged in developments of devices that will wrap packages of the type described above. Also, the development includes the adaptation of these new wrapping devices to existing types of wrapping machines."

The picture on the preceding page shows combined in one automatic unit a cleaning, filling and screw-capping machine developed by the Pneumatic Scale Corporation. These machines are all tied together and synchronized so that the three operations are continuous as one unit. It was developed for use by the gin and whiskey distillers upon repeal of the 18th Amendment.

Perhaps the most interesting feature of this unit is the dry-cleaning feature. Heretofore, the only possible way to clean some bottles was to either wash them with water or with live steam, both processes involving considerable trouble and considerable expenditure for equipment to perform the work. In this unit the bottles are dry-cleaned right on the filling machine and cleaned in a manner which removes all sawdust, coal dust or lint as the bottles pass along to the filling department. The dirt removed is not scattered about the room but is carried away to a tank.

Considering manufacturers of automatic machinery, all of them state that the principal aim is toward increased capacity or output, this to be procured through higher speed of operation and calling for improved lubrication, electric motor drive and anti-friction bearings. Variable speed transmission has recently been adopted by 75 per cent of these manufacturers, undoubtedly primarily for the purpose of permitting an accurate speed control that will make possible the operation of the machine at the highest possible speed, taking advantage of the different permissible maximum speeds when the machine is handling different wrapping materials or types of packages.



How thirty-five manufacturers of food processing and packaging machinery have improved their products

With further reference to the types of drive or transmission, the short-center flat belt drive and the V-belt drive appear to be getting equal attention. Another feature that is getting the attention of 55 per cent of the reporting manufacturers is the application of thermostatic metals for the automatic control of the temperature of the electric heaters used for heating cellophane and waxed wrappers for the sealing operation.

Among designers of slicing, canning, and dairy equipment the principal aims are toward more automatic operation, greater precision in use, increased capacity of output, increased efficiency, and greater compactness. More than 60 per cent of the designers in this group of products are resorting to built-in drives and controls.

Reported recent adoptions of anti-friction bearings, self-lubricating bearings, and redesign for better lubrication by 60 per cent of these manufacturers indicate the attention being given to this feature. An equal number of manufacturers in this group report that they are putting special efforts on improved lubrication and also report the recent adoption of anti-friction bearings and self-lubricating bearings.

Gas-heated mixing machine of Ben-Moore Manufacturing Company uses stainless steel and Monel for appearance and corrosion resistance

As in packaging machinery, two-thirds of the manufacturers report recent further adoptions of variable-speed transmissions and V-belt drives.

With reference to construction materials, because of the corrosion-resistance problem, stainless and alloy steels are receiving great attention and there is an extended use of laminated or "clad" metals.

Indicative of the product development that has been going on in this field is the mixing machine of the Ben-Moore Manufacturing Company. The older type mixers were largely of cast iron and because of their massiveness required many hours to heat to the required temperature. The new style mixer, here illustrated, uses stainless steel on the outside for appearance and sanitation, and Monel metal on the inside of the container. Not only is Monel rust-proof, but its smooth surface does not creat as much friction as sheet steel with the ingredients when they are being mixed.

In grinding and mixing machinery, surface-hardening materials are naturally receiving great attention. With increased efficiency the aim of all the reporting manufacturers, and greater compactness desired by 85 per cent of them, built-in drives and controls with better electrical controls are receiving most attention.

Parts and units recently adopted by designers in this group include flexible couplings, anti-friction bearings, self-lubricating bearings, V-belt drives, silent chain drives and roller chain drives, speed reducers and flexible couplings. These were reported by 60 per cent or more of the manufacturers in this field, and 80 per cent are making more use of welding.

▼ ▼ ▼

Designers of Home Equipment Stress Improved Operation

Although appearance ranks first, efficiency and automatic operation are receiving increasing attention

(Left) The Dumore electric cocktail shaker made of silver plate and equipped with a universal motor

In design principles, the 1.5 gal. per hr. Williams Oil-O-Matic has all the features of the larger unit

COMPARING the results of the product development survey conducted in 1932 with those of the present survey, it seems that many companies consider that they have approached the ultimate in the appearance of their product, and are now putting greater effort on improving the serviceability. Based upon the same number of manufacturers, more automatic operation is receiving 110 per cent greater attention, increased efficiency of operation is receiving 100 per cent greater attention, devices and materials to minimize vibration are receiving 45 per cent more attention and improved lock washers and locking devices, 65 per cent more. A similar comparison shows that approximately equal emphasis is placed upon restyling for new form, better surface finish, improved color schemes, the adoption of corrosion-resisting materials and lubrication.

The evident shift in the emphasis that is being placed on various design factors is not surprising when considered in the light of recent developments. During 1932 and the years immediately preceding, there was a tremendous emphasis placed upon the form and finish of products, particularly in this consumer group class. Startling results were obtained and in many instances competition between different products of the same kind was primarily on the basis of eye-appeal. New form styles and new color combinations were evolved, some extremely bizarre in their effects but most of them of a pleasing nature. The former vanished rapidly; the latter remains with us. Today the appearance factor has been developed to such a degree of perfection that manufacturers can no longer compete on the basis of eye-appeal alone. Attractive product appearance must be maintained, but it is evident that manufacturers are now swinging back to a more intensive development of the operating features of their product.

Considering some of the unit parts that contribute primarily to improved performance, the number of manufacturers that have recently adopted improved bearings, motor drives and controls, and thermostatic devices is a direct indication of the trend toward improving the operation of machines and equipment for the home.

More than 55 per cent of the manufacturers indi-

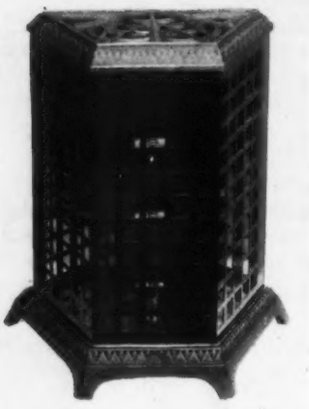
cated that they are now making their products with closer tolerance and fewer numbers of parts. Undoubtedly a large contributing factor in this direction is the increased use of rolled, drawn or extruded shapes, zinc and aluminum die-castings, and molded parts. Their use naturally permits of closer manufacturing tolerances without increased cost. Indeed, all of the items mentioned above with the addition of welded construction, which is now receiving the attention of almost exactly one-half the number of reporting manufacturers, contribute to reduced manufacturing cost.

One interesting feature not illustrated in the chart is the price class that is receiving greatest attention. In the reported survey last year, more than three times as many manufacturers were aiming for a lower price class than for a higher price class. This year, however, the manufacturers are almost exactly equally divided concerning the price class of their new designs.

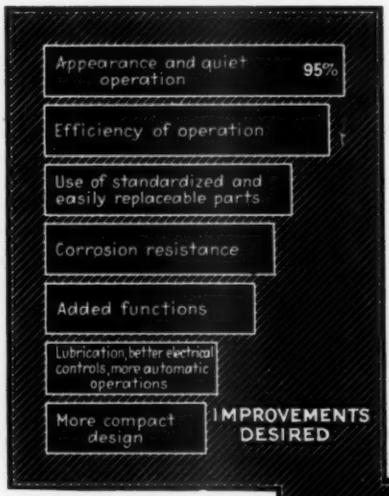
Only household equipment of a mechanical nature is included in the chart shown here. With reference to manufacturers of stoves, ranges, furnaces, electric heaters and similar products, 85 per cent of those companies place emphasis principally on improved color schemes and surface finish. Also, 70 per cent consider restyling for improved form a prime consideration. Corrosion and high-temperature resistance, automatic controls, replaceable units and improved locknuts and nuts locking devices are considered specially important by almost exactly 50 per cent of the reporting manufacturers.

In the case of automatic control, this refers primarily to gas and electric heaters and cooking ranges to be equipped with thermostatic and time-temperature controls. With reference to increased efficiency, this is reflected in the design of cooking ranges by improved burners and more heat insulation.

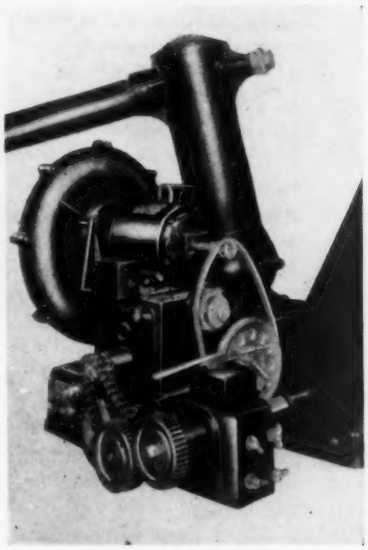
In the washing machine of the Prima Manufacturing Company, washer mechanism and centrifugal dryer and water pump are all driven from one motor through a single V-belt



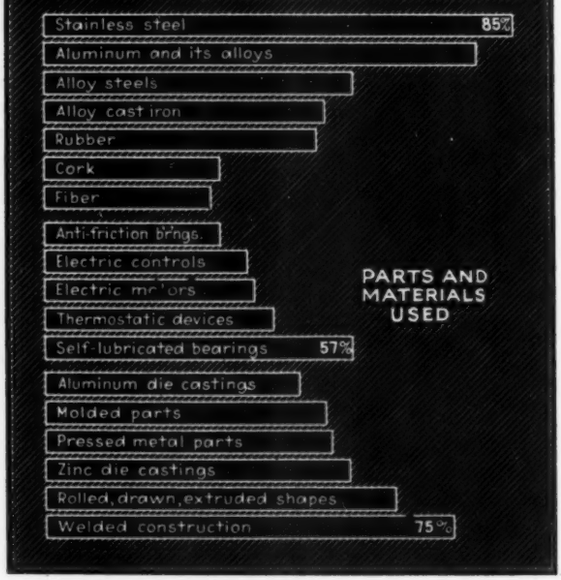
The electric heater of the Thermodor Electrical Manufacturing Company has top and base of aluminum alloy casting for portability



How thirty-eight manufacturers of domestic washing machines, vacuum sweepers, oil burners, refrigerators and similar home equipment have improved their products



In the new Motorstoker the coal hopper is replaced by a swivelling conveyor extending to the coal bin, making the operation of this unit complete automatic. One design feature is a Monel shaft running in oilless bearings



It is also reported that manufacturers of gas ranges are giving more attention to the desirability of equipping their product with safety devices to prevent the flow of gas when the burners are not lighted. Attention that is being focused upon cases of asphyxiation as the result of gas burners being extinguished by the boiling over of liquids, is the main factor that will probably compel manufacturers to make this improvement.

During the past year improvements in the art of die-casting have resulted in greatly extending the use of this type of construction. Zinc die-castings are now made commercially with walls only 0.0155-in. thick. A few of the products wherein advantage has been taken of this advance in the art of die-casting, include clock cases $3\frac{1}{2}$x$4\frac{1}{2}$ and $2\frac{1}{2}$-in. deep with walls 0.040-in. thick, electric heater housings $8\frac{1}{2}$x$10\frac{1}{2}$ and 4 in. deep with 0.055-in. wall thickness, and spark plug seals for airplane engines, die-cast with 0.0155-in. wall thickness.

Rolled, drawn and extruded shapes are finding wider application for the reason that more engineers are finding that they can often modify their designs so that parts will have the same constant cross-section.

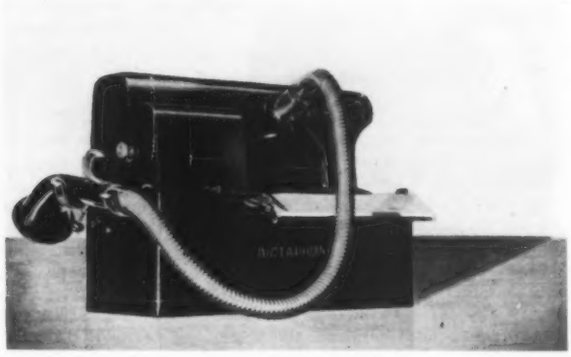
▼ ▼ ▼

New Standards for Precision Devices

Simplified operation and new functions characterize business machines. More attention being given to automatic operation and improved appearance of instruments and devices

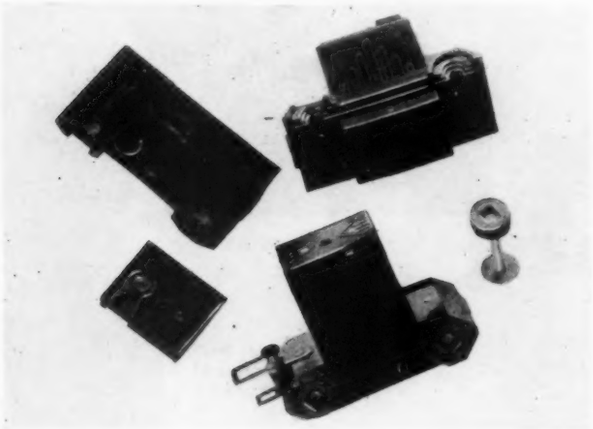
IN THIS group of products is included business machines, cameras, optical apparatus, hospital equipment, recording and measuring instruments, scientific apparatus and miscellaneous products.

Because of the great divergence in the character of the various products represented in this group, it is impossible to set forth specific design aims and trends. Thus, six of the seven reporting manufacturers of business equipment place particular emphasis on added functions and more automatic operation. Instrument designers naturally continue their efforts toward greater precision while camera and photographic equipment designers set forth the added requirements of greater compactness as well. Increased safety factors and automatic controls are trends in the design of sterilizers, cookers, X-ray apparatus and similar equipment.



Improved appearance, compactness and greater protection from dust are the principal feature of this new Model 12 Dictaphone

Assembled and exploded views of the midget camera designed by the Norton Laboratories and made almost entirely of molded plastics



One design aim is common to all of the products in this group. Sixty-five per cent report special emphasis being placed on restyling to give new form, better surface finish, improved color schemes and materials adopted for improved appearance. These facts are borne out by the nature of the materials, types of construction and finishes that are receiving the attention of the designers in this field.

Eight manufacturers report recent adoption of molded parts, four other manufacturers expect to adopt molded plastics; seven engineers recently adopted rolled, drawn or extruded shapes, while two expressed the probability of doing so; six designers have gone more into die-castings and two expect to do so.

With reference to popular types of finishes in this group of miscellaneous products, thirteen manufacturers have recently adopted lacquer, three expect to do so. Cadmium and chromium plating are being used more extensively by four manufacturers, an equal number of them expecting to use this type of finish in the near future.

In the field of business machines, the Monroe Calcu-

lating Machine Company has developed a new Adding-Calculator, here illustrated, which combines completely automatic multiplication with fully automatic division. Multiplication operations on this machine have been simplified to a point where it is merely a matter of setting up factors in the machine and pressing the multiply lever. Where a constant multiplier is used, the figure may be locked in the machine to eliminate the necessity of resetting for each calculation. This machine has the Monroe "Shadow-Ring" keyboard. The keys and board are designed so that upon pressing the keys a circular space between the keys and the board gives the appearance of a dark circular ring surrounding the numeral. This makes it easier to quickly note the key that has been pressed, the black circle attracting the eye.

Illustrative of recent developments in photographic equipment are the new camera for aerial survey and the new midget camera produced by the Norton Laboratories, Inc.

Hospital Equipment

The new sterilizer developed by the American Sterilizer Company is one of the remarkable developments in the field of hospital equipment. As explained by W. B. Underwood, research engineer of that company:

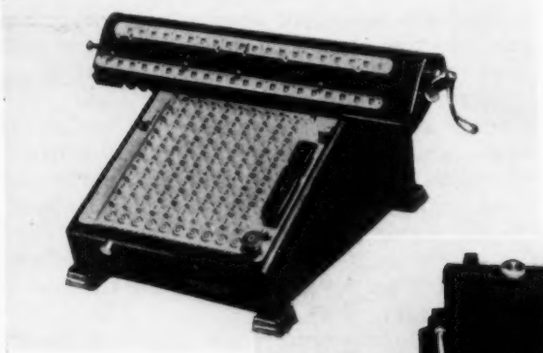
"To compensate for inequality of temperature in the sterilizing chamber resulting from the presence of air, it has been customary to operate some sterilizers at pressures as high as 20 to 30 lb., whereas a steam pressure of 15 lb. per sq.in. is sufficiently high for all surgical sterilization. Even with the higher pressure, the temperature in the lower portion of the sterilizing chamber would be dangerously low because of the air which gravitated to the bottom. But in spite of all this and the fact that air-free saturated steam will penetrate gauze, gowns, surgical dressing and the like more quickly, little attention has been paid to this fundamental requirement of air elimination and resulting temperature.

"All the above deficiencies have been eliminated entirely in our new design sterilizer. We place a thermostatically controlled air valve in the discharge outlet leading from the bottom of the sterilizing chamber. This valve automatically remains open until all air in the chamber has been expelled and reopens automatically when an accumulation of air causes a drop in temperature. If the discharge is clogged or inoperative, preventing the escape of air, the temperature cannot rise. With this new sterilizer the operator is required to gage the sterilizing performance not on the basis of the pressure but according to the temperature indicated by a thermometer located in the air discharge.

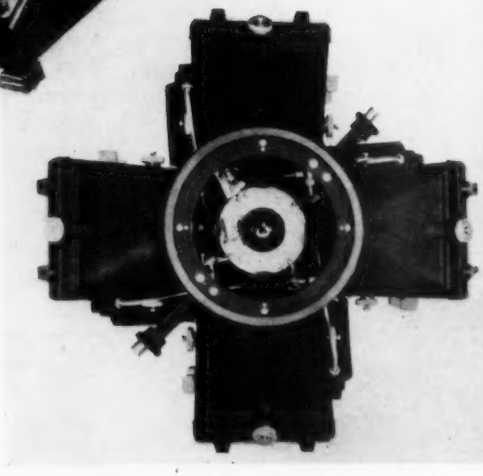
"In this new design of sterilizer, all surgical sterilization can now be carried on at a maximum pressure of 15 lb. with the full assurance of complete sterilization. There is a greater factor of safety than has ever been obtained before, because a uniform temperature throughout the sterilizing chamber is assured."

Indicative of the other mechanical improvements that have been made in this new sterilizer, the walls of the sterilizing chamber and the steam jacket surrounding the chamber are of Monel metal. The door frames are nickel-bronze castings, while the locking arms which hold the door securely under steam pressure are heat-treated stainless steel. The use of these non-corrosive metals eliminates all exterior applied finish and provides an apparatus entirely free from corrosion and approximately twice as strong as former models which have been constructed from brass, bronze and copper, with some exterior applied finish which has in many instances resulted in an electrolytic action that was quite rapidly destructive.

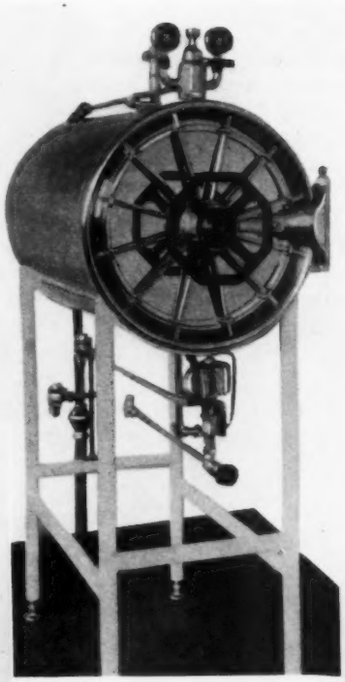
Monel, nickel-bronze and stainless steel predominate in the new sterilizer of the American Sterilizer Company. A thermostatically controlled air-valve has greatly increased the efficiency of its operation



The new Monroe adding - calculator has been designed primarily for more automatic and quieter operation



The new Fairchild camera used for aerial mapping has five lenses whose shutters are operated simultaneously



Molded plastic thermostat case designed by the Richardson Company

Getting a New Product Under Way

A comparison of the development procedure of four companies engaged in manufacturing different products

AS MANY product engineers know to their sorrow, the best technical design in the world may fail of commercial success because some step in the development process has been either entirely overlooked or mishandled.

For the benefit of those subscribers to *Product Engineering* who are interested in the whole question of product development, from conception of the idea to the profitable merchandising of the finished product, we have asked several readers to outline the procedure of their respective organizations. Note that they are more or less in agreement on most of the steps, but that there is considerable divergence of opinion as to the order in which they should be taken.

No. 1

C. Powers

Vice-President, The Stanley Electric Tool Company.

1. New product suggested by someone:
   - (a) Salesmen
   - (b) Officials or staff
   - (c) Friends
2. Sales research covering:
   - (a) Competing lines, if any
   - (b) Demand
   - (c) Method of selling
3. Patent search.
4. Preliminary design.
5. Cost estimates:
   - (a) Capital expenditure
   - (b) Product
6. Build models.
7. Test fully and experiment with models.
8. Proceed with patterns, jigs, fixtures, gages; etc.
9. Start production.
10. Advertising.

No. 2

Lucien W. Mueller

Vice-President and Works Manager, Mueller Company.

1. Suggestion for a new product:
   - (a) From product development department
   - (b) From sales department
   - (c) Customer's suggestion
2. Determination of requirements of product as to performance, cost, etc.
3. Approval of sales department to develop product.
4. Development of product to fulfill requirements including estimated cost of product and equipment.
5. Field tests of new product.
6. Patent search for conflicting art and applications on patentable features of new product.
7. Approval of sales department to manufacture.
8. Making of regular drawings, records, and manufacturing equipment.
9. Test run through factory to check manufacturing process and equipment.
10. Approval of manufactured product by engineering and sales department.
11. Issuance of sales literature, advertising and information to salesmen.

No. 3

Marc Resek

Engineering Department, Perfection Stove Company.

1. Preliminary test of basic principles involved.
2. Search of patents on prior art.
3. Study of competing products.
4. Market study by sales department.
5. Experimental development.
6. Experimental testing of finished product.
7. Field tests of finished product.
8. Cost estimate.
9. Re-design of product to reduce manufacturing cost.
10. Revised cost estimates.
11. Preparation of patent applications.
12. Preparation of production drawings and tools.
13. Preparation of sales and advertising campaign.

No. 4

R. P. Dinsmore

Assistant Factory Manager, The Goodyear Tire & Rubber Company.

1. Research to discover product.
2. Research to develop method of manufacture.
3. Patent search for conflicting art and applications to protect product and process.
4. Semi-plant development in order to:
   - (a) Establish method of production and uniformity and quality of product
   - (b) Establish costs
   - (c) Feel out market acceptance
5. Patent coverage on applications of product.
6. Sales research to determine market.
7. Sales exploitation to get market or consumer acceptance.
8. Sales service and further product development to meet needs which arise.
9. Design and estimate cost of equipment based on sales expectancy.
10. Budget approval.
11. Organize sales force or employ agency.
12. Advertise.

Improved Closures for

Felt seals, metal sealing rings, labyrinths, grooves

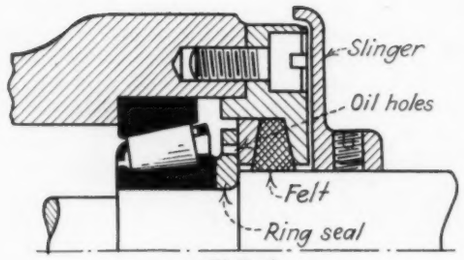


FIG. 1

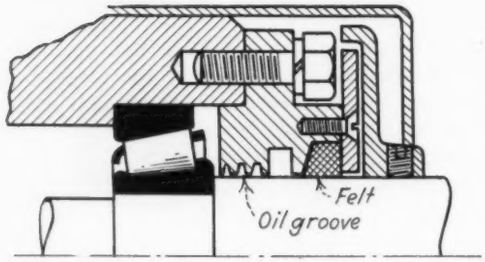


FIG. 2

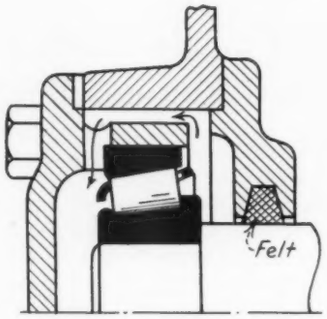


FIG. 3

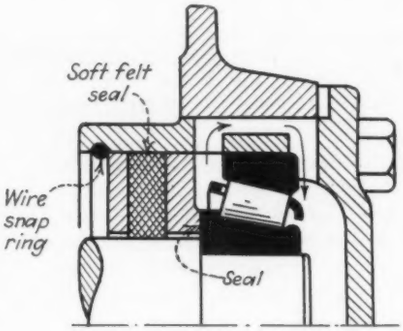


FIG. 4

ALFRED M. WASBAUER

Fig. 1—Combination metal ring seal, felt and slinger closure, an economical and efficient type. Oil holes must be drilled through the sealing rings to insure oil saturation of the felt.

Fig. 2—Combination oil groove, felt groove and slinger closure for excluding water. This design is cheaper but less effective than that shown in Fig. 1.

Fig. 3—Conventional felt groove closure, which can be reasonably oil-tight only as long as the felt makes good contact on the shaft.

Fig. 4—Permanent metal seal held in place by a wire snap ring and bearing against inner ring of the roller bearing. Owing to the large section of the felt ring, a soft felt should be used.

Fig. 5—Double metal seal closure for drenched or submerged operation. The two seal rings and the felt ring within the end cap must be held stationary and must be drilled to permit saturation of the felt.

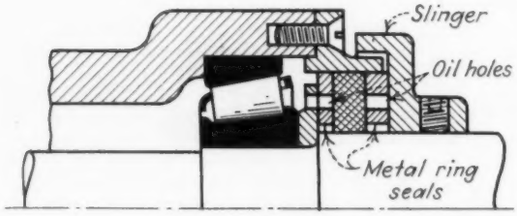


FIG. 5

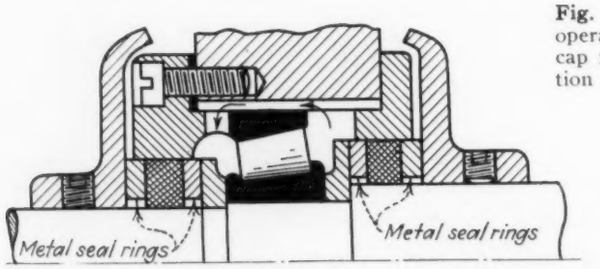


FIG. 6

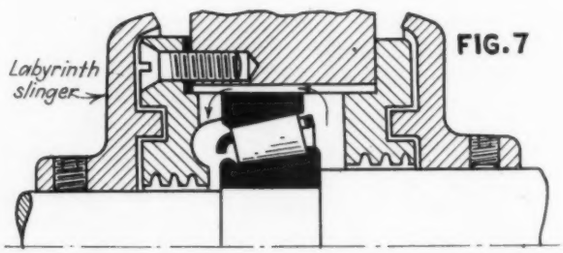


FIG. 7

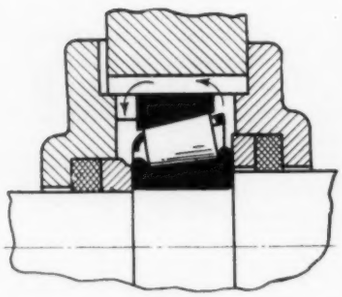


FIG. 8

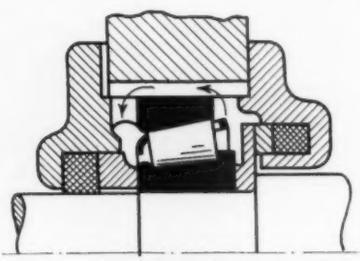


FIG. 9

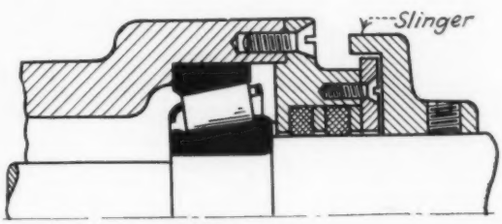


FIG. 10

Anti-Friction Bearings

and slingers as used for sealing bearing housings

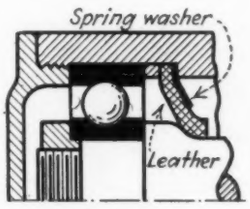


FIG. 11

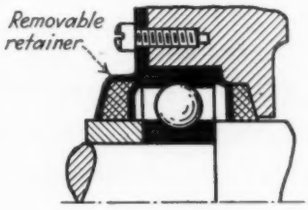


FIG. 12

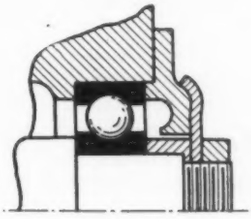


FIG. 13

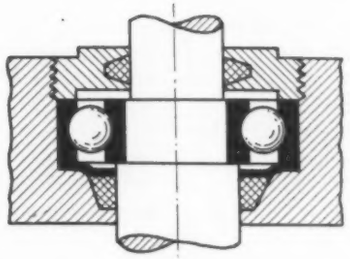


FIG. 14

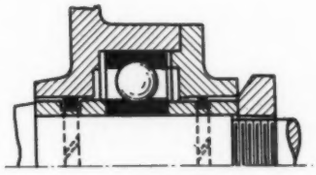


FIG. 15

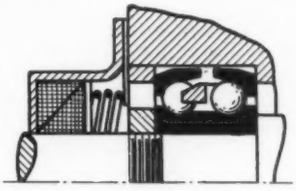


FIG. 16

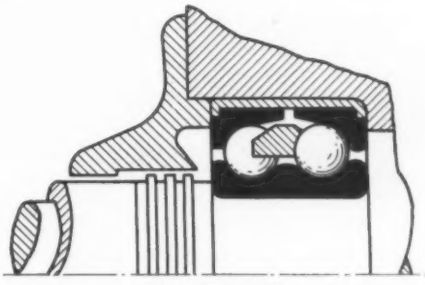


FIG. 17

Fig. 6—The metal seal rings must be drilled as in Fig. 1 to permit lubrication of the outer seal.

Fig. 7—Labyrinth slingers in combination with annular oil groove. This closure requires accurate machining of the slingers. Its ability to exclude water when the shaft is at rest is doubtful.

Figs. 8 and 9—Two designs of closures using felt and metal sealing rings.

Fig. 10—Combination double felt groove and slinger closure, a type used in some paper making machinery as an effective method of excluding water from the bearings.

Figs. 11 to 18—Various types of closures using leather, felt, oil grooves.

Figs. 19 to 26—The closures shown here are of the same general design as those shown in Figs. 11 to 18, but are also equipped with metal sealing rings for the more positive retention of lubricant and exclusion of dirt.

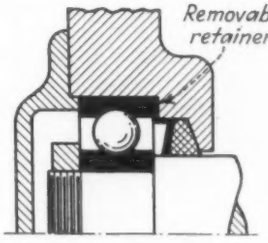


FIG. 18

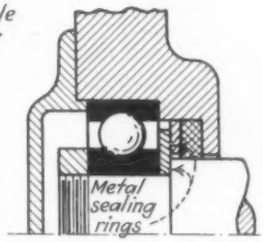


FIG. 19

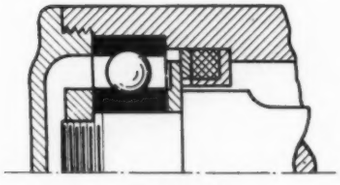


FIG. 20

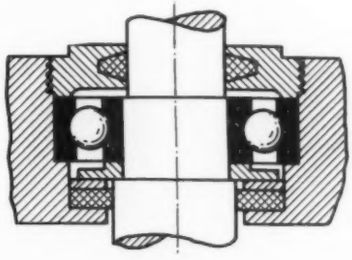


FIG. 21

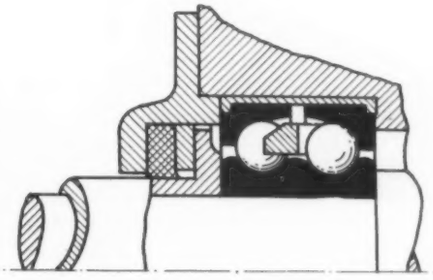


FIG. 22

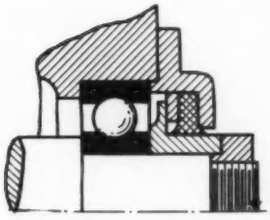


FIG. 23

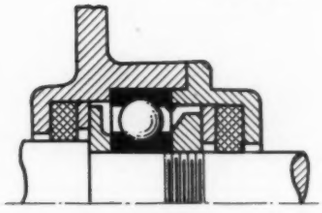


FIG. 24

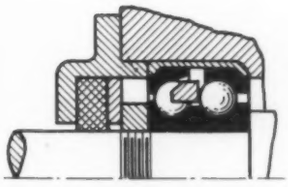


FIG. 25

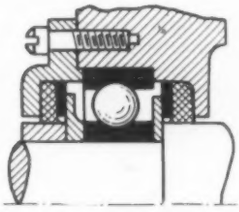


FIG. 26

Mechanical Design of Thermostatic Bimetal Elements

Deflection equations for the three general types of bimetal elements, a discussion of the design factors and a table of the properties of the bimetals commonly used

H. D. MATTHEWS, *Chief Engineer, W. M. Chace Valve Company*

IN MANY types of temperature indicating and controlling devices, thermostatic bimetal has proved to be a reliable material for the temperature-sensitive element. To meet the wide variety of movements required many shapes of elements are used. Three general groups, straight strips, U-shapes or hairpins, and coils are considered standard and may be used for producing linear or angular motion for the opening or closing of contacts, releasing a tripping mechanism or rotating a pointer over a graduated dial. It may be of interest to review the relative amount of motion of these various shapes of bimetal elements as they respond to a change of temperature.

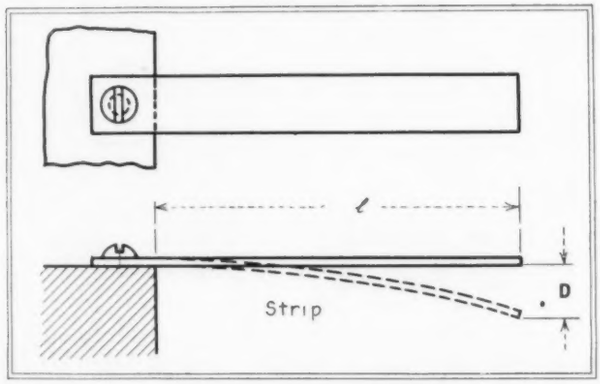
In the deflection of a bimetal strip of given materials and for a specified change in temperature the length and thickness are the predominating factors that determine the amount of movement. For a straight strip, as shown in Fig. 1, the movement at right angles to the strip varies with the square of the length and inversely with the thickness. The motion is expressed by:

$$D = \frac{k(T_1 - T)\, l^2}{t}$$

D = movement of free end
$T_1 - T$ = degrees temperature change
l = active length of strip
t = thickness of strip
b = width of strip
k = constant, depending on metals used

The formula is limited for practical use to a movement that does not exceed more than one-fourth of the length of the strip.

Fig. 1—For a straight strip, the maximum deflection D should not exceed one-fourth of the length l



The deflection of a U-shape, Fig. 2, is just one-half that of a straight piece and is expressed by:

$$D = k(T_1 - T)l^2/2t$$

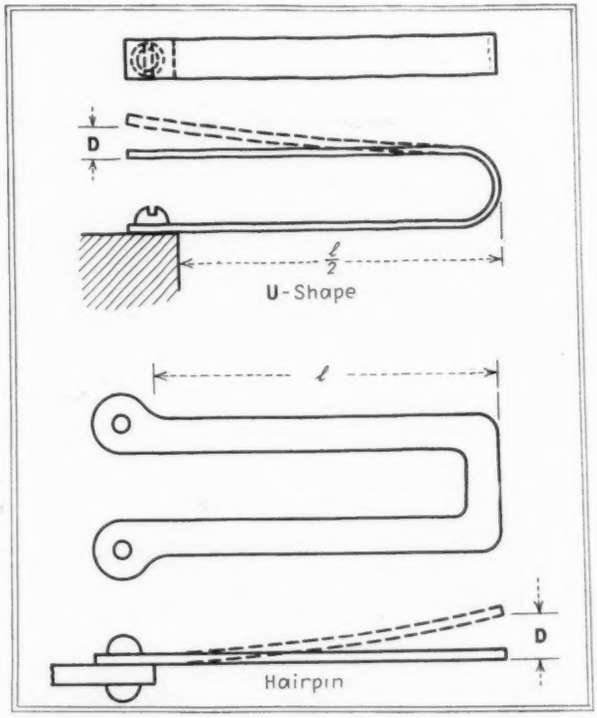
For the hairpin shape the formula given for Fig. 1 applies. For the circular form, Fig. 3, the free end motion is one-third that of the straight strip, or:

$$D = k(T_1 - T)l^2/3t$$

This formula can be used with sufficient accuracy until the distance D equals one-fourth the diameter of the circle.

For dial instruments requiring equally spaced calibration marks the coil form of bimetal element is used.

Fig. 2—Deflection of the hairpin shape is the same as that of the straight piece, while the "U" has only half the deflection of the straight piece



The rotation of the coil is proportional to the length of the strip used, in contrast to the square of the length of the straight strip. For preliminary estimate the activity may be considered the same for either the spiral or helix form as shown in Fig. 5. The rotation is expressed by:

$$A = k(T_1 - T)l/t$$

where A = degrees rotation.

Coils may be wound to open or close with increase of temperature with no effect on the degree of rotation. Coils that open with rise in temperature are usually preferred on account of increased circulation between the turns. With the helix coil there is a slight elongation as the coil unwinds. This change in length is too small to be of any value from a control standpoint, but has to be allowed for to prevent binding from end thrust.

Relative to their ability for doing work, there is no advantage in selecting any particular one of the different shapes covered by the above formulas. Sufficient metal must be used to keep the maximum stresses within favorable working values. The manufacturers of bimetal have data on the elastic limits of the various alloys so that by the use of simple beam formulas suitable sizes of elements can be determined to keep the working stresses within the proper limits.

In some applications where the temperature differential is only a few degrees and considerable strength is required, the mass of the element, because of its thermal capacity, may prevent a quick response to change in temperature. There is no general rule that can be used in regard to this condition, and it is best to make up a sample for preliminary test under actual conditions of service.

It will be noted that in the formulas given the temperature change is directly proportional to the deflection for all the shapes. This is only true for a specified range of temperature for any specific type of bimetal. Fortunately, most of the available bimetals on the market have a reasonably wide working temperature range with uniform bending. Many controls are calibrated from — 50 deg. to + 600 deg. F. At higher temperatures the rate of deflection is greatly reduced. Some types of metals that are suitable for temperatures up to 1,000 or 1,200 deg. F. have but little bending at these elevated temperatures. The physical properties of the alloys used as well as methods of fabrication determine the practical operating range of the product.

In some applications the movement may be restricted because of mechanical interference or stops, and care must be exercised to avoid a permanent set in the element, thereby resulting in a faulty calibration or sequence of operation. If the temperature is not carried above the restrained position to any appreciable amount, or if the element can be left free to move, favorable results will be obtained.

It is probably unnecessary to point out that a tabuation of the important characteristics of bimetal elements must include such factors as accuracy, sensitivity, uniformity and endurance. The manufacturer meets such requirements as these by careful chemical analysis

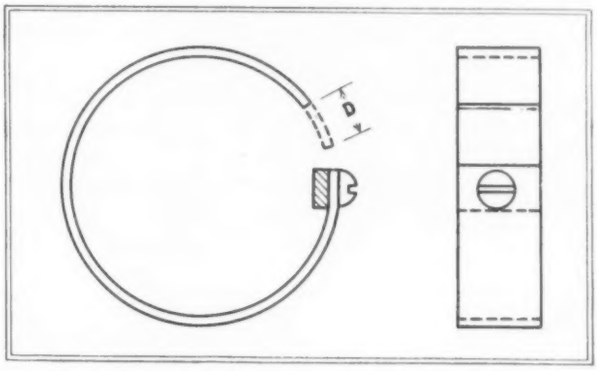


Fig. 3—The free end of the circular shape has only one-third the deflection of the straight piece

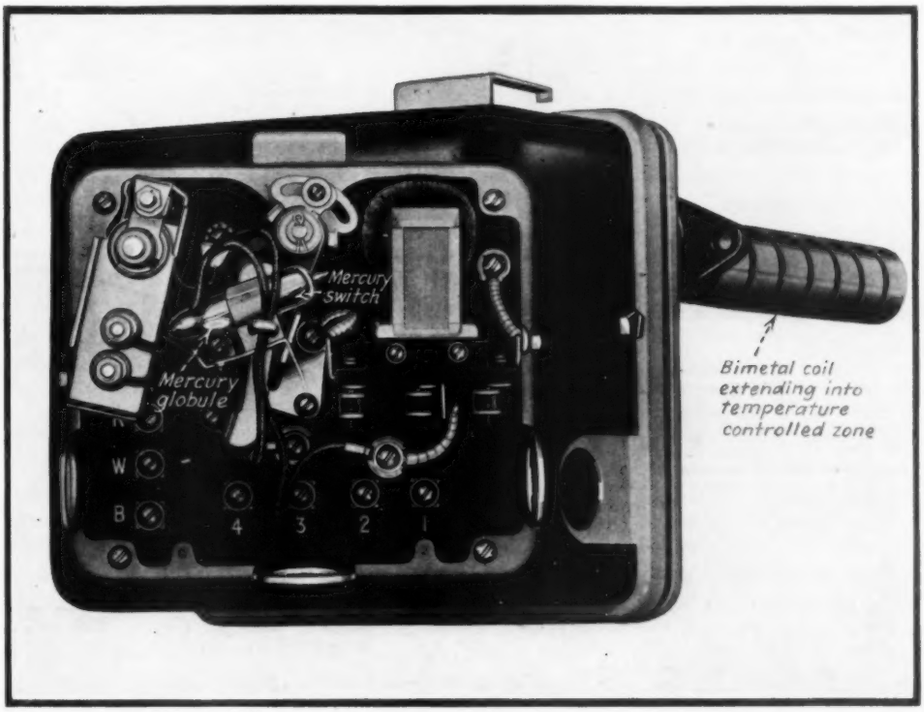


Fig. 4 — Completely assembled instrument and view of the internal mechanism of the Protectorelay of the Minneapolis-Honeywell Regulator Company. The bimetal coil rotates the mercury switch, thereby making ore breaking the electrical contact

and uniform methods during the welding and rolling processes. The limitations imposed upon the finished product are largely determined by the character of the component metals used.

In the final shape, if coil or bent piece, a heat-treatment is necessary to relieve stresses set up in the metal in the rolling and forming processes. This immediate relief of stresses results in an accuracy that otherwise would have to be obtained through a long period of service. It is advisable to obtain from the supplier exact instructions regarding this heat-treatment in order to have it conform with the type of alloys used.

In the growing demand for automatic devices the use of bimetal as a temperature responsive means finds a ready use because of the simple way in which the elements can be handled with ordinary production methods. A few years ago this metal was considered a sort of a novelty or magic metal. Today it is found in dozens of devices with which one comes in daily contact, indicating that its use can be expanded to an unlimited number of applications in a highly economical and satisfactory manner.

In selecting the component metals that go into bimetal fabrication, it is desirable to select materials that have as great a difference as possible in their thermal expansion. This makes it possible to have maximum movement of the completed element under a given temperature change, or reduces the size of the piece to a minimum, which is, of course, economy from the standpoint of installation.

Most of the bimetals on the market are made of materials shown in the accompanying table. Many patents have been issued covering desirable combinations. It is necessary that the metals used not only have a wide difference in thermal expansion but have the same general physical properties as far as welding and rolling are concerned.

It will be noted from the table that, of the metals listed, the combination of brass for the high-expansive side and 36 per cent nickel-iron (Invar) for the low-expansive side has the greatest ratio of thermal expansion. This ratio has a direct bearing on the activity of the metal but the activity is not directly proportional to this ratio. If we consider the activity of the element just mentioned as 100 per cent, the activity of the element using 42 per cent nickel-iron as the low-expansive side and 67 per cent nickel-23 per cent copper for the high-expansive side is just one-half, even though the ratio of the coefficients of expansion of its component elements is 1:3 as compared to 1:12 of the former. This is explained by the fact that the expansion coefficient of the materials used for the low-expansive side increases rapidly with increase of temperature, and hence the movement of the bimetal at high temperatures is greatly reduced.

The table indicates maximum temperatures at which a uniform deflection would be obtained and on some of the types it is possible to carry the temperatures up to 1,000 to 1,200 deg. F., although little movement would be obtained at these higher temperatures. It is obvious that maximum temperatures to which the bimetal element can be subjected depend upon the physical properties of the two metals used.

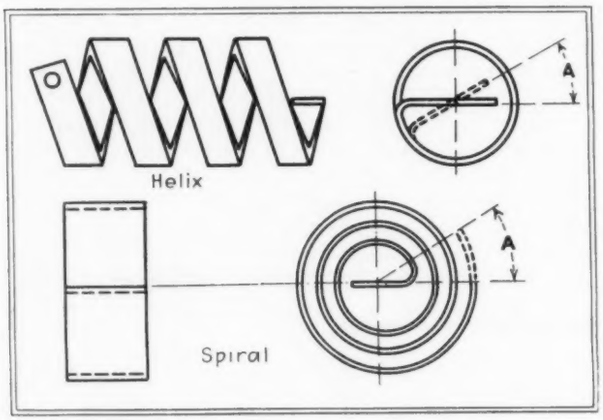


Fig. 5—Dial instruments requiring equally spaced calibrations use bimetal elements in the form of coils

Typical Bimetals, Their Ratio of Thermal Expansion and Maximum Temperature for Active Deflection

Bimetal Element		Average Ratio of Thermal Expansion of Component Elements at 100 Deg. F.	Maximum Temperature for Active Deflection Deg. F.
Low-Expansive Side	High-Expansive Side		
36% Ni-Fe	Iron	1:6.5	400
36% Ni-Fe	Nickel	1:8	430
36% Ni-Fe	67% Ni-23% Cu	1:8.5	460
36% Ni-Fe	Copper	1:10	400
36% Ni-Fe	22% Ni-8% Cr-Fe	1:10.5	480
36% Ni-Fe	Brass	1:12.5	300
40% Ni-Fe	Brass	1:5.5	300
40% Ni-Fe	67% Ni-23% Cu	1:4	550
42% Ni-Fe	67% Ni-23% Cu	1:25	600
42% Ni-Fe	22% Ni-8% Cr-Fe	1:3	750

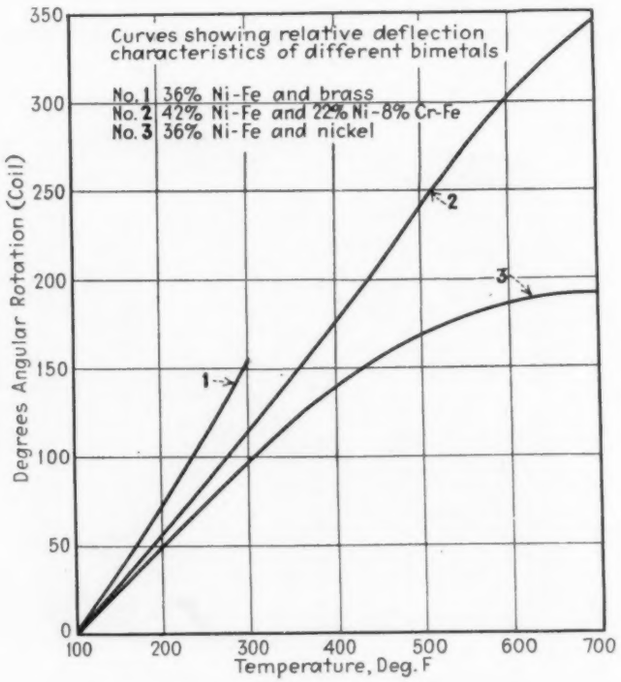


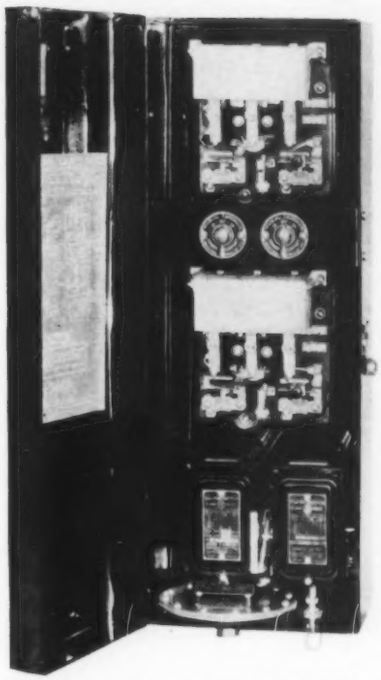
Fig. 6—Curves showing relative deflection characteristics of three commonly used bimetals

The Control and Protection of Motors—II

Magnetic Control in the Modern Machine

PORTER STROTHER
Engineering Department, Square D Company

The flexibility of automatic controls and the operation of magnetic and thermal protective relays, is discussed authoritatively in this second article of the series on motor controls



Selective duplex pump control for heating system. Either motor may be started or stopped from a push button station, vacuum switch, or float switch

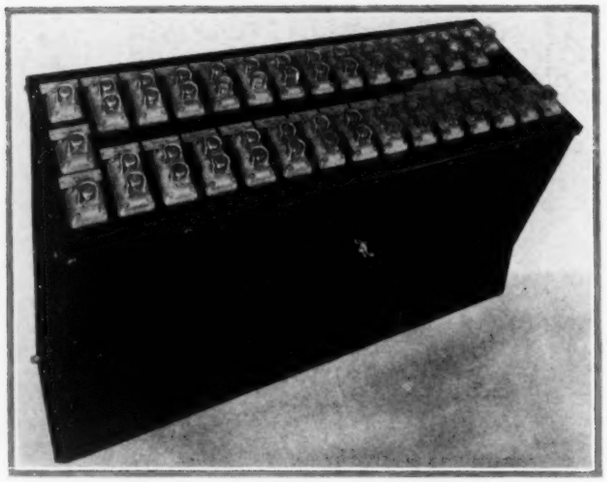
DEVELOPMENT of magnetic controlling devices to their present high degree of performance has been one of the chief factors making possible the wide application of integral electric drive which characterizes modern machines of almost all kinds. It was not alone necessary that the electric motor be developed to its present efficiency, reliability, and compactness, but suitable control devices were required which would equal the motor in these qualities and, in addition, would give to the complete installation a simplicity that would permit its operation by any type of laborer without involving the risk of incorrect operation and damage to equipment.

Developed primarily to permit the remote control of large switches, the pilot circuit operation of magnetic contactors opened an almost limitless field in motor control. The scheme is remarkably simple: electromagnets serve to open and close contactors in the power circuit and it is only the small current carrying circuit through the magnet coils which is brought out of the control box to the push button station, limit switch, or other device used to set the motor in motion or to stop it. Inside the control box it is the same low current circuit in which are placed the various timing and protective relays. The same small device is capable of controlling a fifty horsepower contactor magnet as easily and with the same dispatch as it controls a single horsepower contactor magnet. Single motors for groups of motors controlled as a unit and necessarily controlled from a number of points, as are the driving motors on large printing presses, make the use of magnet controls imperative.

The advantage of having push buttons wherever convenient to the operator and having the more bulky control apparatus assigned to an out-of-the-way place is obvious. It would be impossible in many machines to provide space for the controls if it were not for the unobtrusive push button and its hidden co-worker, the magnetic contactor. Likewise, the simplicity with which low voltage and overload protection are secured recommends magnetic control for the simplest of starters such as those which throw small motors directly across the line. In more complicated installations, the pilot circuit is the only means of reducing to a simple solution the complicated control problem. Motors requiring starting with external resistance, multi-speed motors, reversing motors, and processes involving many motors which must be coordinated with each other according to a definite plan of operation, are all controlled by devices employing timing elements and interlocks to give automatic operation.

Insertion of current limiting starting devices in the connections to large motors is required by almost every power company when necessary to protect other customers on the same line from excessive voltage drops during the starting period of the motor. It often would be unwise to omit such devices even in the few locations where they are not compulsory, since the stresses set up in a motor when suddenly starting it under full voltage would be likely to damage large motors of ordinary design as well as the coupled machinery.

Current limiting starting devices, whether compensa-



From this master control board are operated all the motors of a large coal handling and conveying equipment. Controlling the movements of fully loaded railway cars is one of the functions of this board

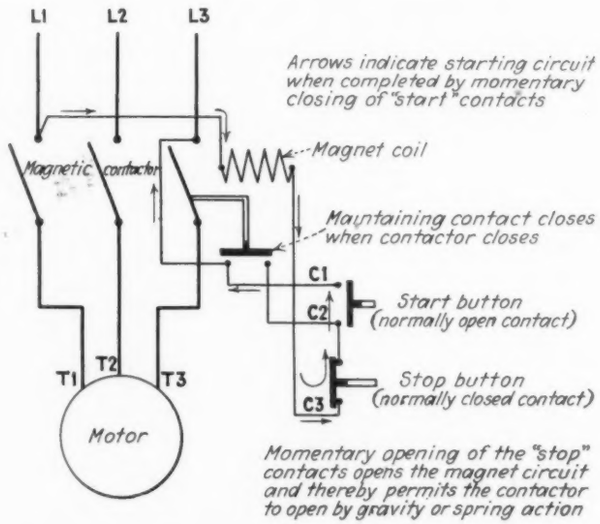
tors, primary or secondary resistors, or reactances, involve two or more steps in their operation. Best operation requires that these positions be held for definite lengths of time. In manually operated starters, the timing is left to the discretion of the operator and damage to the resistor elements may result from holding the switch for prolonged periods in the starting position. Or equally as often, damage may result from excessive current demands and stresses caused by too rapid acceleration. With automatic operation, the proper starting period is predetermined and always follows upon the pressing of a single push button.

Time delay relays may prevent the starting of some apparatus before external conditions have had time to be properly adjusted. Or time delay relays may bring in succeeding steps of a single sequence at some definite time after the first step has been set in operation. In deep-well automatic pump operation, it has been found that water standing in the pipe when the pump stops sets the impeller in reverse motion as it flows down the pipe. To start the motor before the water had all run back and the shaft had ceased its reverse motion would subject the shaft to severe stresses and often cause breakage. To prevent automatic restarting too soon after stopping, a time delay relay introduces a lag between the closing of the float or other pilot switch and the actual closing of the main line contactors. Efficient operation of huge amplifier and rectifier tubes found in radio and motion picture sound apparatus demands that the filaments be heated before the plate circuit is closed. A time delay relay, with its actuating circuit shunted across the filament power supply and its contacts in the pilot circuit of the plate supply contactors, insures the correctness of the time interval and relieves the operator of a troublesome duty in starting his equipment and often preventing unnecessary delays.

Magnetic control makes available to the operator any of the various speeds of the multi-speed motor simply by the pressing of the proper button in a compact push button station. If it is desired that lower speeds be passed through before higher speeds are reached, such a condition is easily imposed and the operator may be required to push the buttons in order of increasing speeds. Or the lower speeds may be passed through automatically with suitable set time intervals for the successive speeds, the motor finally reaching the high speed corresponding to the button that was pressed.

Various machines and processes require conditions under which it is desired to stop, start, or stop and reverse a motor or group of motors. Such operations may be timed with respect to external conditions such as temperature, pressure, or liquid level. In some instances the operations may be a function of some movement on the part of the machine or another motor or they may simply be a function of time. Whatever the nature of the proposed sequence of events, it may be arranged by inserting in the pilot circuit compact and reliable devices such as limit switches, interlocks, time delay relays and even the recently developed photoelectric cell unit, which last opens an entirely new field to automatic control.

Not the smallest of the advantages of magnetic con-



The basis for automatic motor control is the magnetic contactor and the three-wire control pilot circuit shown in the diagram

trol lies in its adaptability to the inclusion of safety features. Most of these have already been suggested. The interlock, either mechanical or electrical, prevents the unintentional closing of a circuit at such times when the position of the machine or other controls makes it unsafe. The magnetic or thermal relay provides any overload protection required and performs its function economically.

The magnetic relay is essentially a solenoid with its coil in series with the load circuit and a pair of contacts in series with the pilot circuit, the contacts being forced open when the armature pulls in. The pulling-in current for the device is adjustable through a wide range of currents for a given relay and the action may be either instantaneous or delayed for several seconds. The delaying action, where employed, is secured by the attachment of a dashpot to the armature of the solenoid. The advantage of this latter feature is evident when one

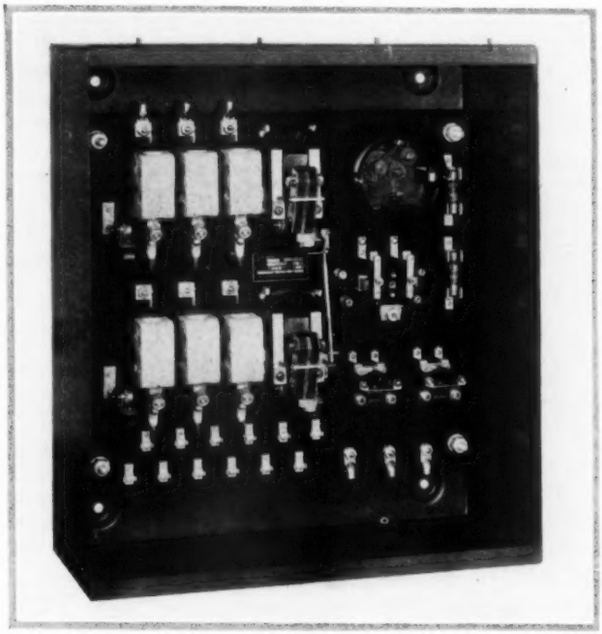
considers that excessive currents of short duration are frequent and harmless but that such currents sustained over a considerable length of time may cause serious damage to the coils of the motor. The ordinary protective devices such as fuses and circuit breakers may be set to pass peak currents, and the magnetic relay be given the task of limiting them to a safe length of time.

The thermal relay operates similarly with the difference that the excessive current produces a heating effect which, if sustained, will operate to open the pilot circuit. In the melting alloy type of thermal relay, the release of a ratchet wheel by the melting of the alloy allows the spring loaded contacts to open. The alloy is confined so that, upon cooling, it again restricts the action of the ratchet wheel, permitting the relay to be reset for operation an indefinite number of times. The familiar bimetallic strip is also employed in some instances where the current passing through it is within suitable limits. The time delay (inverse to overload) feature of the magnetic relay equipped with a dashpot is inherent in both types of thermal relays.

After an overload, it may be desirable to have the relay reset automatically as in applications where the starting button must be pushed each time the motor is started. Magnetic relays and bimetallic thermal relays may be so designed. In other applications, especially where devices such as liquid float level controls and thermostats open and close the pilot circuit, it is desirable to require hand resetting in order to prevent continued recurrences of sustained overloads. All relays may be designed to require hand resetting.

Danger of damage to the equipment through failure of voltage is eliminated in magnetically controlled motor installations. The lowering of the voltage below normal limits allows the magnets to release the contactors as in ordinary stopping. Where the stopping and starting of motors is habitually an automatic function as in well pumps, air compressor, and the like, it is sufficient to keep the circuit open during the period of low voltage and allow the motor to start immediately upon return of full line voltage. Starters so equipped have low voltage release. Where starting is ordinarily initiated by the action of a push button, automatic starting of the motor upon the return of full voltage might involve serious damage to machinery or personnel. Therefore such applications if they are to be protected against low voltage are ordinarily provided with full low voltage protection, three wire control, which does not permit starting until the starting button is pushed in the usual manner.

Reversing washer control. Mechanically interlocked reversing contactors are controlled from a synchronous motor timing device. A definite "power off" period allows the washer to come to rest before reversing. The automatic timing equipment is in turn under the master control of a Start-Stop push button



The mechanical design of control equipment is of first importance to the user of an electrically driven machine or device since the device can be no more reliable than the control. In many applications, a faulty piece of control equipment might occasion losses amounting to many dollars because of the loss of machine production involved. Control equipment has been developed to the point where it is strong enough to stand anything short of violent treatment and where the possibilities of forced shutdowns due to defective controls are exceedingly remote. Wearing parts are easily replaced when long service requires such replacement and the few adjustments ever required are easily and conveniently made. Although the push button is the only part of the control equipment necessarily placed at the machine, the hazardous and destructive conditions found in many industries such as enameling plants, chemical works, and creameries need not bar the placing of the actual contactor equipment with the machine, since protective coverings, proof against water, dust, explosive gases, and the like may be had for most control devices.

Where space economy is of prime importance, it will be found that magnetic controls are generally less bulky than equivalent manual controls and may be assigned to any out-of-the-way space found most convenient. Unit construction of controlling devices facilitates their incorporation as integral parts of many machines and it is common practice for manufacturers to buy uninclosed starters to place in built-in compartments of their machine instead of attaching the controller as an appendage. This quality appeals strongly to the manufacturers of equipment which must be as simple and compact as possible.

The applications of the basic idea of a pilot circuit controlling a magnetic contactor are limitless. Whenever it is desired to have a motor stop, start, reverse, or perform some intricate cycle of operations, it is only necessary to determine under what conditions these events are to be carried out and a grouping of standard devices such as timing devices, limit switches, pressure switches, interlocks, and time delay relays may be designed to perform these functions and perform them without requiring human attention or bulky equipment. And where no difficult problem is involved, it has been found time and again that the added convenience of push button control makes the purchase of magnetic control equipment a minor cost which greatly increases the value of the product.

Design of Dished Heads of Pressure Vessels

C. O. SANDSTROM
Thermal Engineering Company

There is no simple mathematical formula for calculating the stresses in the dished heads of pressure vessels, as any analysis of the behavior of such heads must consider factors that cannot be obtained exactly. The author presents an analysis of this problem and shows how it can be solved in a practical manner

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THERE is no simple formula for the design of dished heads for pressure vessels. An analysis of the behavior of such a head is complicated and involves factors that cannot be obtained exactly.

Referring to the design shown in Fig. 1, full fluid pressure is exerted over the area of the head to the inside edge of the gasket. The gasket, however, does not immediately bar the pressure but reduces it to zero somewhere across its width. It is reasonable to assume that full fluid pressure exists at the inner edge and zero pressure at the outer edge, with the pressure variation represented by a triangle. The resultant pressure is then considered as acting on a circle that passes through the center of gravity of the triangle, that is, through the inside of its middle-third. The average pressure on the gasket is therefore one-half the maximum.

Another uncertainty is the position of the resultant of the pressure of the bolting ring on the outer gasket. The position of the resultant depends on the rigidity, or the resistance to bending of the ring. If there were no bending, the pressure could be regarded as uniformly distributed, and the resultant as acting on the median line; but, since bending exists, the resultant acts on a circle outside of the median line. In the present case, with the outer gasket only $\frac{1}{2}$-in. wide, we would not be much amiss if we regarded the resultant as acting on a circle 0.3 in. from the inner edge of the gasket, or on a circle 6.1-in. diameter.

Still another uncertainty is the total load carried by the bolts. Besides the fluid pressure under the cover and under the gasket, the bolts must carry an additional pressure necessary to make the gasket impervious—assumed by some authorities as high as twenty times the unit working pressure. The assumption of unit pressure over the face of the gasket is sufficient however, if ordinary care is exercised in the selection of the gasket and in tightening the bolts. The additional pressure necessary to make the gasket impervious to the fluid has been designated, "final gasket compression," because it is in addition to the portion of the initial gasket compression that equalizes the fluid pressure.

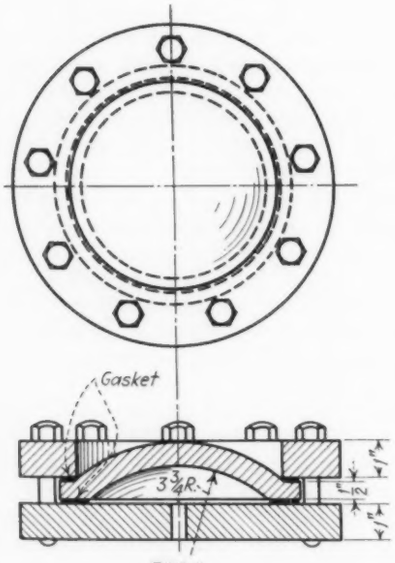

FIG.1

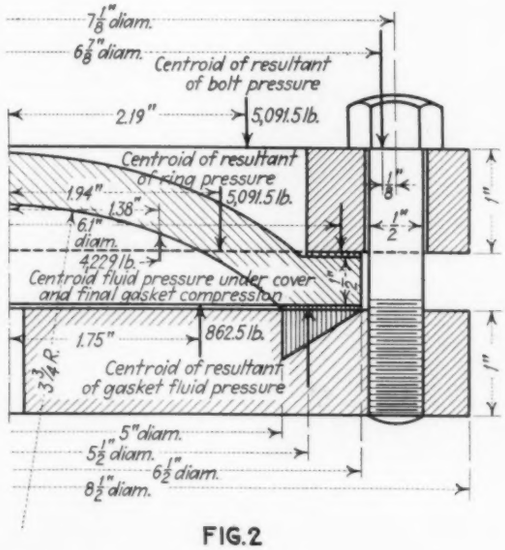

FIG.2

Fig. 1—Type of design of bolted dished head for pressure vessels analyzed and criticized by the author

Fig. 2—Magnitude and position of the various pressure resultants together with the position of the centroids can be determined only by assuming conditions that experience indicates are reasonable

For the cover or ring to fail by dishing or cupping would require uniform resistance all around the edge, a condition impossible to attain in practice because the bolts are usually tightened one at a time. The cover and the ring would therefore fail along a diameter, and under transverse stress.

Scaling the drawing the inside and outside diameters of the cover are found to be 5-in. and 6.5-in., the inside and outside diameters of the bolting-ring 5.5-in. and 8.5-in., and the bolts 0.5-in. diameter. These dimensions and the dimensions given in Fig. 1 are shown in the half-section drawing in Fig. 2.

The first step in the analysis is to determine a safe working pressure for the head or cover. One method is to "mass up" the cross-section on the axis, find the neutral axis, then the moment of inertia and the section modulus. By this method, the section modulus in tension is found to be about 0.85 in.-cubed, and in compression about 0.72 in.-cubed. Since the strength of the tension area is the determining factor, the value 0.85 is

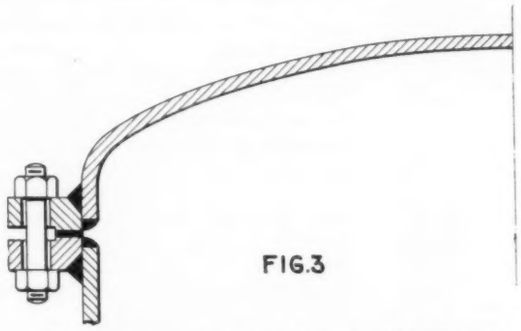

Fig. 3—A conventional design of a dished head with a welded bolting flange would probably be cheaper and more convenient than the construction used in Fig. 1

used. With an allowable stress in the cast iron of 3,000 lb. per sq.in., the resisting moment of the cover is therefore $0.85 \times 3{,}000 = 2{,}550$ in. lb.

In determining the pressure moment, it is assumed that the unit pressure over the area of the gasket is equal to the full fluid pressure exerted over the entire area inside the gasket. The total pressure under one-half the cover is $6.5^2\ \pi\ P/4x2 = 16.59P$. The fluid pressure under the gasket is assumed to vary from maximum to zero, making the average one-half of the maximum, or $(33.18 - 19.64)\ P/2x2 = 3.385P$. The centroid of the pressure under one-half the cover is $6.5x0.212 = 1.38$ in. from the diameter, and the moment of this pressure is $16.59Px1.38 = 22.9P$ in.lb.

The centroid of the fluid pressure under the gasket is $5.5/\pi = 1.75$ in. from the diameter, and its moment is $3.385P\ 1.75 = 5.92P$ in.lb. The sum of the two moments is $28.82P$ in.lb., which is designated as the positive pressure moment.

Point of reaction of the pressure under one-half the cover is under the bolting ring on a circle 6.1 in. diameter. The magnitude of the reaction is $16.59P + 3.385P = 19.975P$ lb. The centroid of the semi-circle is 1.94 in. from the diameter, and the moment is therefore $19.975P \times 1.94 = 38.8P$ in.lb., the negative moment. Subtracting the positive moment from the negative moment gives $9.98P$ in.lb., which, equated to the resisting moment of the cover, gives $P = 2{,}550/9.98 = 255$ lb. per sq.in., as the maximum allowable unit working pressure under the cover.

On the resultant circle under the bolting ring and, consequently, on the bolts themselves, the total force is the sum of the fluid pressure under the head, the fluid pressure under the gasket and the final gasket compression. Adding these values and dividing by two gives 5,091.5 lb. as the force on one-half of the resultant pressure circle.

For the sake of simplicity, assume an even number of bolts instead of the nine shown, so that failure will occur through the bolt holes on a diameter. The bolting ring carries the load transmitted to it by the cover on the assumed resultant circle of 6.1-in. diameter. The negative bending moment was found to be $38.8P$, or 9,878 in.lb.

The bending moment in the bolting ring depends on the position of the reaction under the heads of the bolts. Because of flexure of the ring, the loads in the bolts are not axial, but are eccentric to an indeterminate amount, from experience assumed to be one-fourth the nominal diameter of the bolts. The diameter of the resultant circle is $6\frac{7}{8}$ in., the distance of the centroid of the semi-circle is 2.19 in. from the diameter, and the moment on the diameter is 11,150 in.lb. Subtracting the moment on the 6.1-in. circle gives 1,272 in.lb. This moment requires a section-modulus of 0.1156 in.-cubed, assuming a fiber stress of 11,000 lb. per sq.in. for the steel ring. The modulus of the section through the $\frac{9}{16}$-in. bolt holes is 0.313 in.cubed, so that the ring is capable of clamping a cover carrying nearly three times the pressure under this one.

Under the pressure of 255 lb. per sq.in., each of the nine bolts will carry a load of 1,132 lb., resulting in a direct tensile stress at the root of the thread of 8,984 lb. per sq.in. Assuming that the bolt load is applied with an eccentricity of $\frac{1}{8}$ in., the stress produced by this bending moment must be added to the direct stress. The section-modulus of the root of the thread of a $\frac{1}{2}$-in. bolt is 0.00627 in.-cubed. Dividing the bending moment by the section-modulus results in a stress of 21,950 lb. per sq.in., which, adding to the direct stress of 8,984 lb. makes a total of 30,934 lb. per sq.in. in tension; nearly the elastic limit of ordinary bolt material.

Experience has demonstrated that $\frac{1}{2}$-in. bolts have no place in the design of covers for pressure vessels because of the ease with which they can be twisted off in making up a tight joint. Aside from the high stress given by the stress analysis, it would be advisable to increase the size of the bolts. If $\frac{5}{8}$-in. bolts were substituted for the $\frac{1}{2}$-in. ones, the total tensile stress would be 19,430 lb. per sq.in., still a high stress for ordinary bolt material. A better arrangement would be to use eight $\frac{3}{4}$-in. bolts.

In this particular problem, the bolts are the determining factor, as they are inadequate to develop the strength of the cover. The bolting ring, on the other hand, has an excess of strength relative to the cover as the required thickness of the ring is only about $\frac{5}{8}$ in. The conventional design with a bolting flange on the periphery of the head, as shown in Fig. 3, would probably be cheaper and more convenient.

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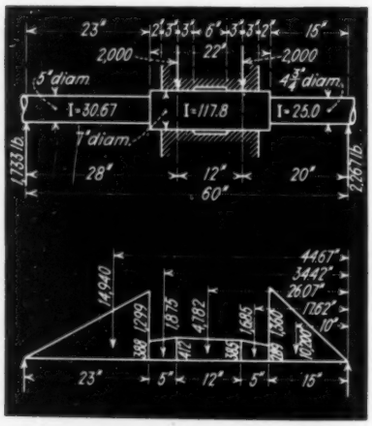
COMMUNICATION and COMMENT

Shaft Deflections by the Method of Elastic Weights

To the Editor:

In the August *Product Engineering*, page 303, an article discusses a graphical method of determining shaft deflections. The following solution using the method of elastic weights requires only a slide rule, and requires less time.

Elastic weights are considered as placed on a conjugate beam as explained in "Structural Members and Connections," by Hool and Kinney, published by the McGraw-Hill Book Company. Assuming E equal to unity to avoid decimals, the elastic weight 23 in. from the left support is $1{,}733 \times 23 \div (1 \times 30.67) = 1{,}299$. Similarly, other values of the elastic weights along the conjugate beam are obtained as shown in the illustration. These results agree with the quantities determined by the graphical method.



Shaft deflections in this problem can be determined by the method of elastic weights using only a slide rule

The center of gravity and the summation of all the elastic weights between the left reaction and a point 23 in. to the right is at a distance of 44.67 in. from the right reaction. In the same manner, the summation and location of center of gravity for the other elastic weights are determined as shown in the illustration.

After all the elastic weights are located on the conjugate beam the left and right reactions are found to be 16,471 and 17,011, respectively. The deflection at any point along the original beam is equal to the bending moment at any point on the conjugate beam divided by the modulus of elasticity of the material when E is assumed to be unity as in this solution.

At a point 15.33 in. from the left support or 44.67 from the right end the deflection given by the graphical method is 0.00868 in. Using the method of elastic weight the deflection at this point is 0.00753 in. The difference between these two figures indicates that the loading used in the graphical method should be divided into smaller areas. No deduction was made in the graphical method for the load between the left support and a point 15.33 in. to the right.

Using the method of elastic weights the maximum deflection occurs where the shear in the conjugate beam is zero. This point is found to be 27.15 in. from the left end of the beam at which point the maximum deflection is 0.0092 in. From the graphical method the point of maximum deflection is given as 25.58 in. from the left support with a value of 0.00922 in. Although the deflections as determined by the two methods agree, the graphical method gives the point of maximum deflection at a distance of 1.57 in. farther to the right. —A. W. FISCHER
Philadelphia, Pa.

Answering All Letters Helps Restore Confidence

C. W. HINMAN
Orlando, Fla.

Business letters should receive the same careful attention now as in 1929. A prompt reply to all letters is a very important part in the recovery of normal times, and has a favorable psychological effect. Many firms fail to reply to inquiries in which there appears to be little or no advantage to be gained. If they receive an inquiry for a position, some firms even fail to extend the usual business courtesy of a reply. Delay in acknowledgment may result in the inquirer believing that the business has gone out of existence, and this belief may be circulated. Big business has usually been built upon a large number of small things done correctly.

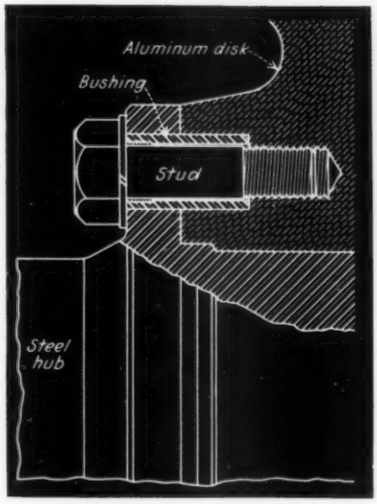
In an item in a recent number of a technical journal a certain product was said to be manufactured in a midwestern shop. An inquiry to this shop brought the reply that they did not manufacture anything of this kind, and the reply omitted to state that although they did not make the product they had built five machines for another firm that was doing the manufacturing. Such an omission is inexcusable in good business ethics and undoubtedly results in loss of business. These strenuous times cannot be used as an excuse to ignore the courtesy of a suitable reply to every inquiry. If every business would comply with this one courtesy it would help considerably in re-establishing confidence.

Flanged Connections to Aluminum Disks

J. S. CARPENTER
York, Pa.

In providing a torque connection from a flanged steel shaft to an aluminum rotor or disk, steel bolt threads bearing upon aluminum threads are unsatisfactory because of the high localized stresses at the threads. In the construction shown in the accompanying figure no torque load is carried by the aluminum threads.

Bushings turned from seamless steel tubing carry the entire bearing load, while the thread carries only the tension load and the bending moment tension. A short, fine pitch thread in the bore of the bushing provides for easy removal of the bushing from the stud. On account of the increased diameter of the bushings, the projection into the aluminum hub can be shortened considerably without increasing the bearing pressure. The bolt fit need not be as close as for an all-steel bear-



Bushings around the studs take the torque loads off the aluminum threads

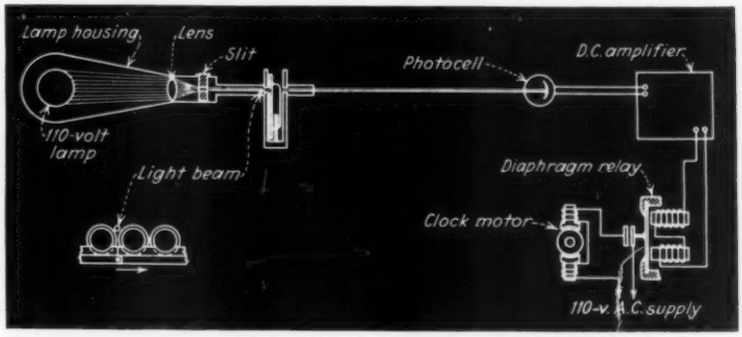
ing, so that a light tapping fit of the bolt body in the bushings is allowable. The cost of this construction is also reduced by the fact that no keys are required to distribute the torque load upon the aluminum disk.

Photo-Electric Counting Device

To the Editor:

In adapting the counting device shown on page 391 of the October *Product Engineering* to operate by photo-electric control the arrangement shown in the accompanying illustration was developed. As in the previous device, the container caps were fed past the light beam at a constant rate so that the light interruptions were of uniform length.

Illumination for the photocell was supplied by an ordinary 110-volt lamp inclosed in a housing. The light from the lamp was directed by a lens through a slit and across the path of the caps so that the light was intercepted by the edge of the cap. The photocell impulse was sent through a d.c. amplifier and operated a diaphragm-type relay which in turn supplied current to a small self-starting synchronous clock motor. A dial geared to the clock motor then indicated the count. The photocell amplifier and microphone switch responded to a high rate of impulses very well, but some difficulty was experienced in obtaining a clock motor capable of responding to the rapid current impulses.



A mechanical counter was replaced by this photo-electric device imposing no load on the light paper caps

Concluding Solutions to the Gear Problem

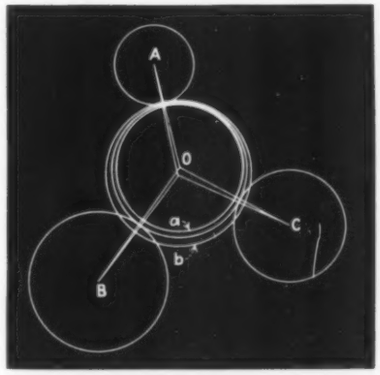
Solutions to the problem of the mongrel gear drive submitted by C. A. Wiken in the August number are concluded in this issue with two more contributions. Whereas the previously presented solutions merely solved for the pitch radius of the common mongrel drive gear, the solutions given here carry through the calculations to solve for the pitch and number of teeth in the various gears.

To the Editor:

Only by infinite good luck does the calculated inner circle in Mr. Wiken's problem contain the nominal pitch module integrally, and thus the analytical solution is debarred. Such a gear drive can be satisfied only by gears of non-standard pitch, but standard cutters must be used for all the gears. In previous experience with such problems a good solution has always been obtained by the following empirical methods.

Satisfactory numbers of teeth and pitch are selected, and the gears are drawn to the largest convenient scale. A circle *a* or *b* whose diameter contains the nominal pitch module integrally, is described in such a position that to the eye the overlap or separation of the circles is proportional to the diameters of the outer circles, as indicated in the accompanying sketch. Any two of the center distances are measured, and from these measurements the other center distance is calculated. When the center distances and the numbers of teeth are determined for the three pairs of gears their actual pitches are established. In most cases the inner gear will have three different pitch circles. The gear blank must then be made of such a diameter that all of these circles will be within the teeth. The diameters of the blanks for the outer gears will then be twice the center distances minus the outside diameter of the inner gear plus 4 modules, the module being that of the standard generating cutter.

Whenever the center distance of a pair of gears is greater than standard, and both are generated by the same standard cutter, the pressure angle is increased from that of the cutter, and decreased when the center distance is smaller than standard. This factor should be taken into account when



A satisfactory mongrel gear drive may require that the common gear run with three different pitch circles

selecting the cutter. Also, if the overlap or separation of the original circles is large compared with the numbers of teeth, the gears may have excessive backlash, for generation is not at the actual pitch circles. Although it is possible to calculate the thickness of the teeth at each of the pitch circles, these calculations are so involved as to justify cutting the outer gears to mesh with the inner gear at the proper center distances.

—Francis W. Shaw
Heywood, England

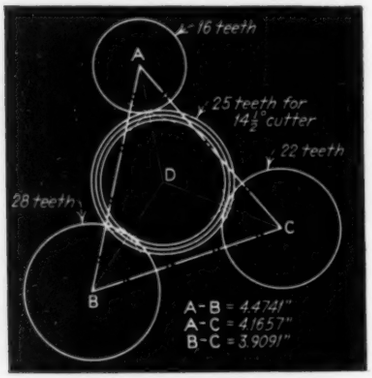
To the Editor:

A solution that gives only the diameter of a circle tangent to the three given circles fails to satisfy the requirements since the problem is one of a gear drive. The four gears must have comparatively small integral numbers of teeth and pitch diameters proportional to the tooth numbers.

A graphical layout on a large scale shows the diameter of the middle circle to be approximately 2.685 in. Since the diameter of the circles are given in multiples of 0.100, it is assumed

that 10 diametral pitch teeth are desired. Thus, the teeth for the three gears number 16, 28 and 22, while the middle gear has approximately 26.85 teeth, obviously impossible. The following solution is based on the availability of a gear generating machine, and the data given provide complete detailed information on a suitable set of gears. For greater convenience the term module, the reciprocal of the diametral pitch, is used. Since the module is the definite increment of diameter per tooth in any gear, this term conveys a clearer meaning than diametral pitch.

Three solutions are possible using a 10 diametral pitch. The teeth may be cut on a hobbing machine with a 14½-deg. pressure angle, or with a 20-deg. pressure angle, or may be cut with a pinion cutter on a Fellows shaper with a 20-deg. pressure angle. Because of the widespread use of the 14½-deg. hob, only this solution will be given. To develop the formulas in the accompanying table for the pressure angle, outside and root diameters, and other quantities would require too much space. They are all developed from the geometrical features of the involute curve, and are arranged in the order required for calculation.



If the four gears have comparatively small numbers of teeth, the common drive gear must run at a different pitch diameter for each of the three mating gears

The middle gear will be smaller than the 28 tooth gear, and larger than the 16 and 22 teeth pinions. From a large scale layout it is found that the middle gear may have 25 to 27 teeth. A few trials with different combinations of center distances indicates that the 25/28 pair runs on 2.73-in. center distance at 0.1030188-in. module, and the 25/22 pair on 2.44-in. at 0.1038298-in. From these two center distances the triangle *BCD* is formed, and the distance *AD* is calculated to be 2.15847. The angle at *A* is found to be 53 deg., 39 min., 30 sec.; at *B*, 59 deg., 8 min.; at *C*, 67 deg., 12 min., 30 sec. For the 25/16 pair with the center distance of 2.1585 in. the module is 0.1052927 in.

Table I

Formulas for Calculating Gears

$$M = 2C/S \quad p = nM/2 \quad P = NM/2$$
$$\text{Cos } \alpha = m \cos \beta / M$$
$$F = 0.500 + 1.933{,}3565\ (\phi - 0.0055{,}4484)$$
$$A = C - m\ (SF - D)$$

N = number of teeth in gear
n = number of teeth in pinion
S = sum of tooth numbers
C = center distance
M = running module
m = module of hob or cutter
D = working depth of hob for 1 module
α = running pressure angle
β = pressure angle of cutter or hob
ϕ = tan α — arc α (radians)
P = pitch radius of gear
p = pitch radius of pinion
F = root radius function
A = working depth

Table II

	25/28 pair	22/25 pair	16/25 pair
Center distance, *C*	2.7300	2.4400	2.1585
Module, *M*	0.1030188	0.1038298	0.1052927
Pressure angle, alpha a	19°59′9″	21°10′55″	23°8′58″
Driver pitch radius	1.28774	1.29787	1.31616
Driven pitch radius	1.44226	1.14213	0.84234
Working depth	0.18442	0.1785	0.1660

Table III

Pair	25/28		22/25		16/25	
	Pinion	Gear	Pinion	Gear	Pinion	Gear
Outside radius	1.3707	1.5252	1.2352	1.3707	0.9537	1.3707
Root radius	1.1890	1.3251	1.0411	1.1890	0.7712	1.1890
Addendum	0.0830	0.0830	0.0931	0.0729	0.1114	0.0546
Working depth	0.1660		0.1660		0.1660	
Pitch line thickness	0.1670	0.1567	0.1656	0.1606	0.1829	0.1479

Using the formulas in Table I, the dimensions given in Table II are found.

The driving gear therefore runs at three different pitch diameters and three different pressure angles. While not common, this feature is desirable for gear drives such as this one. Since the working depth varies with the root radii and the number of teeth it is necessary to use the smallest value, 0.16598 as the working depth for all three ratios. The addenda of the 25/28 pair are made equal to one-half of 0.16598, and the outside and root diameters of the 16 and 22 teeth gears are made to correspond. Assuming a clearance of 0.0157 built on to the point of the hob tooth, Table III gives outside and root radius, and addendum.

—Arthur L. Wilder
Wethersfield, Conn.

Furniture Ornaments

C. F. Scribner
Asheville, N. C.

Designers are often reluctant to improve the appearance of furniture and radio cabinets through the use of ornaments because of the expense involved in their production. By specifying the following production methods, composition ornaments can be made at a reasonable cost, especially in limited quantities.

The design is laid out and hand carved from a block of wood, and this master carving is then used to make a mold from which production is secured. The material for the mold is made as follows: Six pounds of orange shellac are melted and 3 oz. of oil of tar added. Four pounds of soapstone, 4 lb. of emery flour and 4 oz. of French chalk are thoroughly mixed dry and added slowly to the melted shellac and oil of tar, stirring vigorously. The mixture is then poured into a box using the master carving as the pattern, and after the mixture cools the pattern is removed.

Using this block as a mold, the ornaments are cast from a composition made up as follows: 13 lb. of white glue and 14 lb of resin are heated separately until melted, and the resin then added to the glue. One quart of glycerin and three quarts of linseed oil are added, and 19 lb. of whiting is stirred in making a mixture the consistency of putty. The hot mixture is then firmly pressed into the mold. After removing the castings from the mold and allowing them to set for a few hours, the ornaments are ready for use. In applying them to the cabinets, the ornaments are made flexible by steaming and can then be bent to any shape and attached by gluing. Colors may be added to the mixture to make black, blue, brown, red or any shade.

Drawings can be readily found by title when a card such as this is filed for each drawing

NUMBER AND TITLE CARD	11-6-32 Date	6756 Dwg. Number
Approvals Record Clerk ☐ Chargeman ☐ Draftsman JONES	TITLE FITTING - FRAME #6A - LONGERON - STATION 17	
XM-22 Model	-1 Assem.	-2 Ford.	-3 Opp. Hd.	Ch. #

Unnecessary Waste

R. C. NELSON
Kensington, Conn.

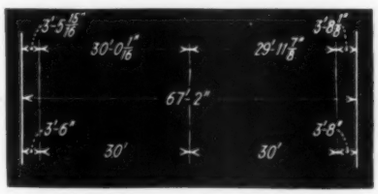
Designers constantly hear the refrain "keep costs down," even while crude extravagance flourishes unheeded. For example, in an assembly drawing showing a silent chain the draftsman was required to spend eight hours in drawing each link and pin in its full visible length. Then the teeth on a pair of spiral gears were all carefully drawn and the spaces darkened, adding nothing to the value of the finished drawing.

Another waste a little less obvious is the waste that occurs from indirect designing. In drawing up a job the draftsman gets the information as well as he can, but not being a designer naturally overlooks some important points. Nevertheless, he is required to hand his design to the chief draftsman who in turn hands it over to the designer. Then, when the designer finds that something has been omitted or added contrary to the customer's wishes, additional designing time is required. Why not have the designer work with the draftsman?

Common Sense in Dimensions

R. M. BIGLER
Brooklyn, N. Y.

Lack of attention in keeping principal machinery dimensions in even figures, as illustrated for example in catalogs of some electric motor manufacturers, increases the opportunity for making mistakes and makes calculations more cumbersome. In laying out a machine having a total length and three main center lines, as given in the accompanying figure, the upper dimensions may be selected as a matter of detailing. But as far as the utility of the machine is concerned, the lower dimensions can be obtained by a designer who carefully avoids fractions. If these machine dimensions enter into calculations involving sines, cosines, or other trigonometric functions, or if the dimensions are involved in squares or square root computations, the use of fractional numbers creates more work and makes opportunities for error.



Whole-number dimensions reduce opportunities for errors in checking and calculation

A Record of Drawing Titles

H. L. LACKMAN
Philadelphia, Pa.

Since most drawing file systems are based on drawing numbers, it is often a difficult task to find a drawing when the only information available is a general idea of the subject or title of the drawing. This situation can be eliminated through the use of the "number and title slip" shown. The title is filled in by the draftsman and then checked for correctness and given to the file clerk. After a number is assigned by the file clerk and placed on the slip along with other necessary information the title slip becomes a permanent file card. In addition to facilitating future reference, the wording of all drawings is kept consistent.

Right Triangles

F. OYEN
Brooklyn, N. Y.

Right triangles with sides of whole numbers often can be used to simplify calculations and decrease the probability of errors. Eighteen of these triangles shown here have angles from about 6¾ deg. to 43½ deg. in steps of about 1 deg. in the smaller angles and about 2 deg. in the larger angles. Wherever these triangles can be used the angles can be laid out quickly and accurately without using protractors or trigonometric tables, and many fractional numbers can be avoided.

NATURAL FUNCTIONS OF RIGHT TRIANGLES
WHOSE SIDES ARE WHOLE NUMBERS

145, 17, 144, 6°44′	1 1/16″ 9″ 9 1/16″	sin 0.11725 cos 0.99310 tan 0.11806 cot 8.4701	37, 12, 35, 18°55′	3″ 8 3/4″ 9 1/4″	sin 0.32419 cos 0.94599 tan 0.34270 cot 2.918
113, 15, 112, 7°38′	15/16″ 7″ 7 1/16″	sin 0.13283 cos 0.99114 tan 0.13402 cot 7.4615	125, 44, 117, 20°36′	2 3/4″ 7 5/16″ 7 13/16″	sin 0.35184 cos 0.93606 tan 0.37587 cot 2.6604
85, 13, 84, 8°48′	13/16″ 5 1/4″ 5 5/16″	sin 0.15298 cos 0.98823 tan 0.15481 cot 6.4596	13, 5, 12, 22°37′	2 1/2″ 6″ 6 1/2″	sin 0.38456 cos 0.92310 tan 0.41660 cot 2.400
145, 24, 143, 9°31′	1″ 8 15/16″ 9 1/16″	sin 0.16533 cos 0.98624 tan 0.16764 cot 5.9651	89, 39, 80, 25°59′	2 7/16″ 5″ 5 9/16″	sin 0.43811 cos 0.89892 tan 0.48737 cot 2.0518
61, 11, 60, 10°23′	1 3/8″ 7 1/2″ 7 5/8″	sin 0.18023 cos 0.98362 tan 0.18323 cot 5.4575	17, 8, 15, 28°4′	2″ 3 3/4″ 4 1/4″	sin 0.47050 cos 0.88240 tan 0.53320 cot 1.8754
101, 20, 99, 11°25′	1 1/4″ 6 3/16″ 6 5/16″	sin 0.19794 cos 0.98021 tan 0.20194 cot 4.952	53, 28, 45, 31°53½′	1 3/4″ 2 13/16″ 3 5/16″	sin 0.52831 cos 0.84900 tan 0.62224 cot 1.6071
41, 9, 40, 12°40′	1/8″ 5″ 5 1/8″	sin 0.21928 cos 0.97566 tan 0.22475 cot 4.4494	5, 3, 4, 36°52′	1 1/2″ 2″ 3″	sin 0.59995 cos 0.80003 tan 0.74991 cot 1.3335
65, 16, 63, 14°15′	2″ 7 7/8″ 8 1/8″	sin 0.24615 cos 0.96923 tan 0.25397 cot 3.9375	73, 48, 55, 41°6′	3″ 3 7/16″ 4 9/16″	sin 0.65737 cos 0.75356 tan 0.87235 cot 1.1460
25, 7, 24, 16°15′	1 3/4″ 6″ 6 1/4″	sin 0.27983 cos 0.96005 tan 0.29147 cot 3.4308	145, 100, 105, 43°36′	6 1/4″ 6 9/16″ 9 1/16″	sin 0.68962 cos 0.72417 tan 0.95229 cot 1.050

· NEWS ·

Engineers' Council for Professional Development Organizes

Far-reaching recommendations dealing with a program for accrediting engineering schools, the establishment of a policy for professional recognition of the engineer including a minimum definition of the engineer, and a suggested scheme of uniform grades of membership in the professional societies were agreed upon at the first Annual Meeting of the Engineers' Council for Professional Development held in New York on October 10, 1933. Other matters of importance to the general questions of engineering education and engineering practice were presented at the business session held in the Engineering Societies building. This was followed by a dinner at the Engineers' Club addressed by Dr. Franklin J. Keller, Director of the National Occupational Conference, attended by members of the Boards and important committees of the seven bodies participating in the work of ECPD, as the new body elects to be designated.

This new agency of the engineering profession was brought into being in October 1932 by joint authorization of the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers, The American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education and the National Council of State Boards of Engineering Examiners. Its purpose is the enhancement of the professional status of the engineer. To this end it aims to coordinate and promote efforts and aspirations directed toward the higher professional standards of education and practice, greater solidarity of the profession and greater effectiveness in dealing with technical, social and economic problems. Its immediate object is the development of a system whereby the progress of the young engineer toward professional standing can be recognized by the public, by the profession, and by the man himself, through the development of technical and other qualifications that will enable him to meet minimum professional standards.

ECPD is made up of three representatives of each of the participating bodies. During the past year the work has been carried on under the leadership of C. F. Hirshfeld, a representative of the A.S.M.E., as chairman pro tem. Dr. Hirshfeld presided at the meetings of ECPD.

ECPD operates by studying questions within the range of its functions, making reports and recommendations to the participating bodies. It administers only the procedures approved by the participating bodies and by them definitely assigned to ECPD. Four standing committees deal with four chronological sub-divisions of the general function of ECPD. The first committee, on student selection and guidance, deals with matters relating to the prospective engineering student up to the time of his entry into the engineering school. The second committee, that on engineering schools, serves to bring about cooperation between the engineering profession and engineering schools during the formal educational process. The third committee, that on professional training, is concerned with plans for the further professional and personal development of young engineering graduates, and also of those without formal scholastic training. The final committee, that of professional recognition, has the duty of developing methods whereby those engineers who have met suitable standards may receive corresponding professional recognition.

Student Selection and Guidance

The report of the committee on student selection and guidance was presented by Dean R. L. Sackett, chairman. This committee had analyzed the literature for guidance of prospective engineering students and submitted some constructive suggestions which included the need for stressing the breadth of engineering and reducing emphasis on its technical sub-divisions and of preparing a concise, understandable description of the work of engineers. Further work of the committee will embody studies of vocational guidance by local engineering groups, pre-freshmen camps, and aptitude testing. Cooperation with the National Occupational Council, the Boy Scouts of America and other agencies that are concerned with vocational guidance will be developed.

The significant recommendation of this committee, approved by ECPD, was that the objective of the committee be broadened to include aptitudes that contribute to success in engineering education regardless of the subsequent career of the graduate. This supported the view that an engineering education is excellent preparation for life as well as for the activities and responsibilities of the engineer.

Engineering Schools

The report of the committee on engineering schools prepared under the chairmanship of Dr. Karl T. Compton, was presented by Professor H. P. Hammond. The committee pointed out that the accrediting of engineering schools is being carried on by several agencies between which there is little coordination and that no representative of an authoritative body accredits engineering schools. It recommended that it should be a proper function of ECPD to compose a list of institutions which, after careful investigation, are found to be prepared adequately to offer sound and comprehensive instruction in the various major engineering curricula. Accordingly, they voted to recommend to the participating bodies that ECPD be set up as an accrediting agency for schools of engineering. The basis for accrediting engineering colleges recommended by this committee and approved by ECPD included:

Accrediting is to be applied only to those curricula, graduate and undergraduate, which lead to degrees; curricula are to be accredited on the basis of both qualitative and quantitative criteria, the qualitative being evaluated by inspection visits and the quantitative by data secured from catalogs, publications and questionnaires. The methods of providing funds for carrying on this procedure are to be established before this recommendation is forwarded to the participating bodies.

Professional Training

The report of the committee on professional training presented by chairman Robert I. Rees revealed substantial progress. It has made a survey of a group of junior members of engineering societies to determine suitable and desired assistance that may be rendered to young engineers in planning their self-development. A preliminary form of personal analysis blank has been prepared to assist the individual in making a program for his future development. The committee has made substantial progress in preparing a program of education and training to meet requirements for recognition that will be set by the Committee on Recognition.

Professional Recognition

The report of the committee on professional recognition, prepared under the chairmanship of Conrad N.

Lauer, was presented by Dean J. W. Barker. ECPD adopted the following policy as a guide in fulfilling the committee's purpose:

The profession should establish as the goal of attainment, a series of qualifications for which the young man, whether graduate or non-graduate, may successfully strive continuously from the time he enters upon an engineering career. This goal of attainment, embodied in a certificate, equivalent to the professional degree and having a value recognizable as adequate to entitle the holder to licensing or registration in a state, should be based upon the following features:

(a) Certification should be earned, and not granted as a mark of honor.

(b) The code of educational qualifications should be more advanced than graduation from college, yet attainable by both college and non-college men.

(c) The attainments should be tested individually by examination (written and oral) or the equivalent, and not gaged by personal estimates and testimonials alone.

(d) Educational qualifications should comprise scientific, technical, economic and civic knowledge of a mature order.

(e) The code of experience qualifications should normally make the age of certification fall between twenty-five and thirty.

(f) The ultimate certification into the profession should be the objective to which both the colleges and the professional societies should exert their influence. To this end the colleges should be encouraged to aid by granting the professional degree to those who have been thus certified.

(g) The certificate into the profession should be the means by which the state registration boards would with confidence recognize those essentials which they observe as requisite for the registration of engineers.

(h) And, similarly, the certificate into the profession should be prima facie evidence of technical proficiency for admission into the corporate membership of the societies.

By such a progressive educational program involving selection of proper material, its supervised education, intimate contact with the profession during the apprenticeship stage and the attainment of definite specified educational requirements with concurrent recognition by professional societies, educational institutions, and state laws, it is believed that an identity would be attained by which those who have not developed experience and maturity of engineering judgment would be recognized as assistants in the engineering field, and those who have attained engineering maturity would have an identity universally recognized by the profession itself and the public at large. It is believed that this definition of the engineering profession will be of immeasurable benefit.

ECPD also approved the following minimum definition of an engineer recommended by the committee and voted to request the adoption of this definition by the participating bodies.

The minimum qualifications for an engineer are:

(a) Graduation from an approved course in engineering of four years or more in an approved school or college; a specific record of an additional four years or more of active practice in engineering work of a character satisfactory to the examining body; (the examining body, in its discretion may give credit for graduate study in counting years of active practice) and the successful passing of a written and oral examination covering technical, economic and cultural subjects and designed to establish the applicant's ability to be placed in responsible charge of engineering work and to render him a valuable member of society;

or alternatively

(b) Eight years or more of active practice in engineering work of a character satisfactory to the examining body and the passing of written and oral examination designed to show knowledge and skill approximating that attained through graduation from an approved engineering course and also examinations written and oral covering technical, economic and cultural subjects designed to establish the applicant's ability to be placed in responsible charge of engineering work and to render him a valuable member of society.

In accord with the view that the grades of membership in the various societies should have reasonable conformity with this minimum standard, the committee presented the following designations and minimum specifications which were approved by ECPD for recommendation to the participating bodies for adoption with the stipulation that they are not intended to exclude the affiliation of other persons with any constituent society in a capacity other than the grades of membership indicated below:

Student Member—A person matriculated in an approved school or pursuing studies in accord with the program of the committee on professional training.

Junior Member—A graduate of an approved school or one who has passed equivalent written and oral examinations.

Member — The full-fledged engineer who has passed the requirements in the minimum definition of an engineer.

Permanent officers were elected consisting of the following members of the Executive Committee: J. Vipond Davies, A.S.C.E.; Donald F. Irvin, A.I.M.E.; William E. Wickenden, A.S.M.E.; Charles F. Scott, A.I.E.E.; H. C. Parmelee, A.I.Ch.E.; Robert I. Rees, S.P.E.E.; David B. Steinman, N.C.S.B.E.E. C. F. Hirshfeld was elected Chairman and C. E. Davies, Secretary.

MEETINGS

American Society of Mechanical Engineers—Annual meeting, Engineering Societies Building, New York, N. Y., Dec. 4-8. Ernest Hartford, assistant secretary, 29 West 39th St., New York, N. Y.

American Institute of Electrical Engineers—Winter convention, Engineering Societies Building, New York, N. Y., Jan. 23-26. H. H. Henline, secretary, 33 West 39th St., New York, N. Y.

EXHIBITIONS

Fourteenth Exposition of Chemical Industries — Grand Central Palace, New York, N. Y., Dec. 4-9. Charles S. Roth, manager, Grand Central Palace, New York, N. Y.

National Automobile Show — Grand Central Palace, New York, N. Y., Jan. 6-13.

Designers to Have Session at A. S. M. E. Annual Meeting

For the first time, a session at the annual meeting of the A.S.M.E. will be devoted entirely to the interests of the product engineer. This session, under the direction of Prof. James A. Hall, Chairman of the Machine Design Committee of the Machine Shop Practices Division, will include a paper by Allan H. Mogensen, Consulting Editor on *Factory Management and Maintenance*, on the relation of motion study to mechanical design. Mr. Mogensen presented an article on this subject in *Product Engineering*, in August, 1932. At the same session, Mr. Joseph Sinel, industrial designer, will discuss the work of the artist and his relation to the engineer in a paper, "Appearance in Design."

Correlation of creep data, a report on high temperature tests of 18-8 stainless, and the variation of elastic modulus with temperature are sumjects scheduled for discussion at a session on "Creep of Metals." Applied Mechanics sessions will include a paper by A. M. Wahl on stress concentration at fillets. The use of the membrane analogy with photo-elasticity will be presented by J. G. McGivern and H. L. Supper before the Stress Analysis group.

Of the four papers scheduled for the session on Mechanical Springs, one by D. J. McAdam, Jr. on the Mechanical Properties of Spring Material will supplement his report given at the Chicago meeting.

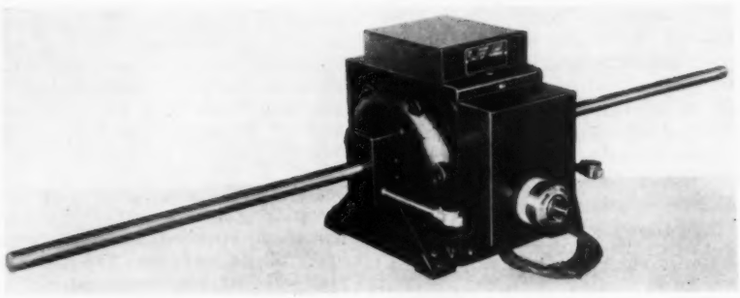
NEW MATERIALS and PARTS

EC&M Bearing Thermostat

For protecting rotating machinery from overheated bearings. Are suitable for use with automatic pumping stations, motor-driven fans, conveyor systems, refrigerating machines. Thermostat consists of a sealed metallic bulb containing a volatile liquid. Bulb is connected through a flexible copper tubing to a one-piece seamless metal bellows, operating double-break, quick-make and quick-break silver contacts. A temperature rise of the bearing expands the liquid, generates pressure in the bulb and bellows, operates the contacts. Contacts are reset manually, after the temperature becomes normal, by pressing the reset button located on top of the thermostat. Thermostats adjusted to operate at 100 deg. C., but can be adjusted in the field to operate at any desired temperature from 85 to 115 deg. C. Either bulb or relay can be installed in any position. The Electric Controller & Mfg. Co., 2720 E. 79th St., Cleveland, Ohio.

Houghton Sta-Put Lubricants

Prepared from mineral oil are polymerized under controlled heat and pressure. This treatment is said to increase the film strength of the oils 40 to 65 per cent, so that oils cling to the bearing surfaces without dripping or spattering as easily as untreated oils. Available in three grades. The 300 series are liquid with consistencies from light machine oils to heavy oils, the 400 series for gear lubrication, the 500 series are greases. E. F. Houghton & Co., 240 W. Somerset St. Philadelphia, Pa.



Holtzer-Cabot Long-shaft Motor

For air conditioning apparatus. It has an extremely long shaft for operating multiple fan units. Low-speed fractional horsepower motor is of the single-phase capacitor type with adjustable varying speed. An all-metal resilient base is said to maintain the shaft in a fixed position and to give quiet operation. Wool-packed bearings are designed to require infrequent attention. Control apparatus is integral with motor. Holtzer-Cabot Electric Co., Boston, Mass.

Minneapolis-Honeywell Industrial Motors

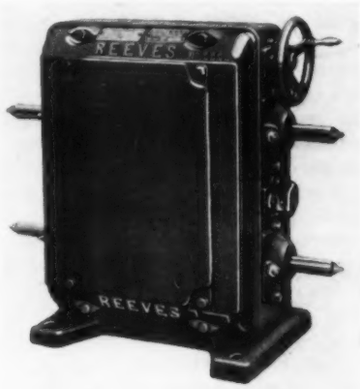
For damper regulation, for direct drive on double-seated regulating valves, in power and industrial processing fields, motor is designed especially for use with automatic controllers or remote station switches. Available as a reversing or non-reversing single-phase, shaded pole induction motor with squirrel cage rotors for 110-220 volt, 25-60 cycle a.c., and 115-230 volt d.c. Motor with gear train and switching mechanism is assembled in a totally enclosed housing. Steel pinions and cut gears of high strength aluminum are packed in grease, require no other lubrication. Electrical connection made through ½-in. conduit entrance. Motors operate from a standard three-wire control circuit. Motor input, 35 watts; torque at final shaft, 8 ft. lb. when 180 deg. rotation requires 30 sec. or longer. Approximate size, $5\frac{11}{16}$x$4\frac{7}{8}$x$6\frac{1}{4}$ in. Also available with an input of 60 watts and 18 ft. lb. torque; dimensions, $6\frac{1}{4}$x$5\frac{1}{4}$x$7\frac{5}{8}$ in. Mineapolis-Honeywell Regulator Co., Minneapolis, Minn.

G. E. Rubber Lamp Cord

Consists of flexible, tinned copper conductors insulated with a 30 per cent rubber compound, covered with a jacket containing a high percentage of pure rubber. Conductors are identified by the color of the insulation. Said to have advantages over silk- or cotton-covered cord for table lamps, extensions, appliances, in that it will withstand hard usage, will not ravel or kink, can be cleaned with a damp cloth. Designated as Type SJ-PO, available in olive green, brown, black, and ivory, and other colors on special order. Carries approval of the Underwriters Laboratories. General Electric Co., Schenectady, N. Y.

Reeves Small Transmission

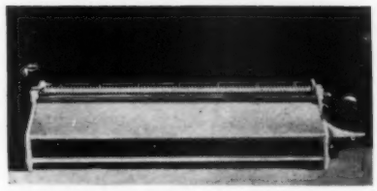
For upright installation in limited space and with low horsepower requirements is less than 14-in. in height. Operating parts of the vari-



able-speed transmission are said to be completely protected from water, chemical fumes, abrasives by the cast iron case. Lubrication is provided by a centralized force-feed system. Transmission provides infinite speed adjustment from 2:1 to 6:1. Height less than 14 in., overall width excluding handwheel 11¼ in., thickness 7 7/16 in., weight 70 lb. Designated as No. 0000, for drives of ¼ to ⅜ hp. Reeves Pulley Co., Columbus, Ind.

Developing Machine for Black and White Prints

Is a developing unit for making black and white positive prints without the use of a negative. Used in connection with a blueprinting machine,



the paper is exposed the same as in making a blueprint. Exposed paper is placed in the developing machine which completes the process without further washing. Machine is said to produce a true black and white positive print more legible and more rapidly than a blueprint. The No. 2836 motor-driven BW developing machine here illustrated is for prints up to 36-in. wide. Charles Bruning Co., 445 Plymouth Court, Chicago, Ill.

J & L Free-Machining Screw Steel

With no change in chemical or physical properties, the free-cutting quality of bessemer screw steel S.A.E. 1112 is said to result from an advance in manufacturing methods. It is claimed that increases in production are obtained either by reducing machining time or by extending tool life. Supplier reports that less energy is required in cutting, and that a finer finish is obtained through less destruction and deformation of the metal in machining. Representative tests on cold drawn material comparing the improved material with the old material of the same composition are given in the accompanying table. Jones & Laughlin Steel Corp., Pittsburgh, Pa.

Armite Lead Lubricant

Is said to form a thin protective film of lead on all contacting surfaces in a bearing. Lubricant has a metallic lead base, said to be free from chemical reaction. Claimed that the lead is in such finely divided parts as to be virtually a soluble or liquid lead within the lubricant vehicle. Lead content ranges from 15 per cent to 65 per cent. For use as a gear and roller bearing lubricant; is said to withstand temperatures up to 430 deg. F. Armite Laboratories, 1450 East 61st St., Los Angeles, Calif.

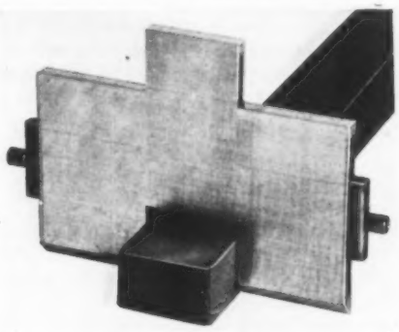
Gits Constant Level Oilers

Provide a visible oil supply while maintaining a constant level in the oil reservoir of the bearings. Glass bottle securely held on a self-closing spring-hinged cover with a compression nut and packing. Bottle is refilled without removing it. Cork packing is used throughout. No glue or cement is used. A short tube clamped to the lower end of the bottle mounting projects downward into the oil reservoir, maintaining the oil level constant at the height of the end of the tube. A one-piece brass forging is used for the body and shank. Available in three types: spring-hinge type as illustrated, bayonet type without hinge, and clamp type in which the spring is replaced by a clamp. Supplied with four pipe thread sizes; bottle sizes are 1¼-in. to 1½-in. diameter, capacities ⅝ to 1⅛ oz. Gits Bros. Mfg. Co., 1846 S. Kilbourn Ave., Chicago, Ill.

PHYSICAL PROPERTIES

	Tensile Strength	Yield Point	Elongation in 2-in.	Reduction in Area	Brinell Hardness	Izod Impact
Old Practice	70,000 to 75,000	53,000 to 72,000	14 (min.)	35 (min.)	155 to 212	8 to 16
Improved Practice	85,000 to 95,000	80,000 to 90,000	14 to 30	42 to 53	171 to 180	8 to 12

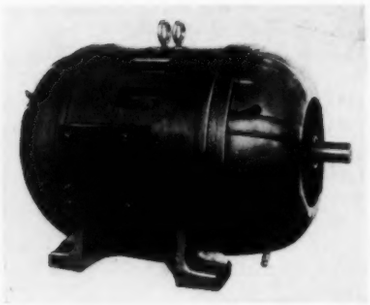
Stockton Profile Gage



Can be used as a temporary or permanent template of any contour. Made of a large number of metal laminations so constructed that after adapting themselves to the contour or angle they are then clamped in position by a tension nut. Gage produces both the profile and the reverse. Available with laminations 0.032 or 0.020 in. thick with 2¼ in. or 4¼ in. throw and with beveled or straight edge laminations, and in lengths from 4½ to 12 in. Gage is recommended for checking on wear on rails, flanges, gears, and for woodworking mills, furniture manufacturers and auto body builders. After the profile has been obtained, the instrument may be placed flat on a drawing board for measuring or may be used as a template for a cut-out. Laminations are duralumin. Stockton Profile Gauge Co., Salem, Mass.

Westinghouse Totally-Inclosed Motors

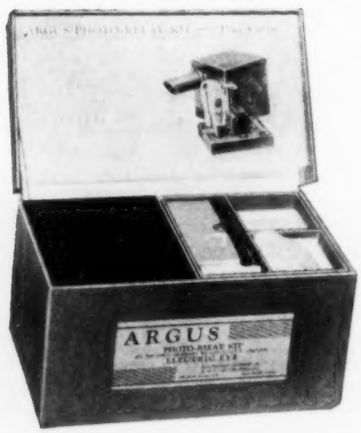
For refineries, agitators, hot oil pumps, gasoline pumps, centrifuges and other Class I Group D hazardous locations. Through the use of a dual ventilation method, inclosed motors up to 200 hp. are said to have mounting dimensions comparable to open types. Frame contains two sets of ducts, one set running from one end of the frame to the other inside the motor carrying internal ventilating air drawn by an internal fan. The internal air is sealed



within the motor. A second set of ducts alternate with the first and pass from each end to the center of the motor carrying external air driven by an external fan. Heat is transferred from the internal air to the frame and from the frame to the external air. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Argus Photo-Relay Kit

Includes a photo-relay, panel assembly base, terminal strips, transformer, photocell, tube sockets and other necessary parts. Instruction sheets for assembling the parts into a variety of installations such as door-openers, illumination control, smoke detection, burglar alarms are included. Photocell is of the photo-emmissive type with a caesium coating, operating a relay by means of a Type 56 amplifying tube. Relay is rated at 100 watts for non-inductive loads. Automatic Musical Instrument Co., 1500 Union Ave., Grand Rapids, Mich.



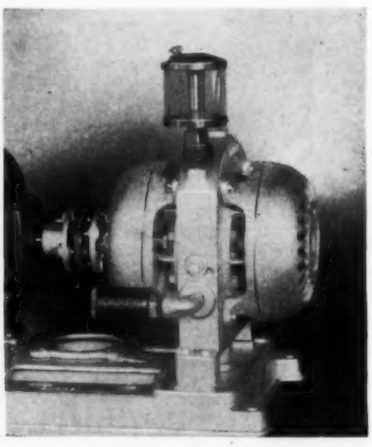
G-M Photo-Electric Relay

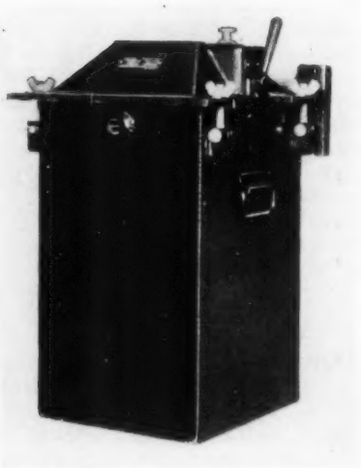
Designated as type FSE incorporates a Visitron F2 cell of the photo-voltaic type, a sensitive relay and an auxiliary electromagnetic relay in a small cast aluminum case 6¼x5⅝x4 in. Provisions are made to mount the cell externally or behind the glass window in the front of the case. Photocell units can be supplied in a weather-proof case. Since no external voltage or amplifier is required the unit can be used in locations not served by electric power lines. With no tubes to require replacing it is said the device will operate for long periods without attention, in controlling lighthouse

beacons, obstruction lights, airway beacons, electric signs, suburban station lights. Auxiliary relay capacity 100 watts, maximum speed of operation 60 per min. Parts can be supplied in any combination as required for the application. G-M Laboratories, Inc., 1731-35 Belmont Ave., Chicago, Ill.

Gast Rotary Pumps

For air pressures from 1 to 25 lb. per sq.in. continuous duty and up to 35 lb. per sq.in. intermittent duty; vacuum from 1 to 26 in. continuous duty. Either vacuum or pressure service can be obtained from the same pump or both when necessary. The design, eliminating springs, pins and gears, is said to be more compact and to use fewer working parts. Fans mounted on pumpshaft supply forced air cooling. Designed for direct connection to motors of 1,200 to 1,750 r.p.m. The Gast Mfg. Corp., Bridgman, Mich.





Explosion-Proof Switch

Is an oil-immersed, combination switch, designated as CR7008 for Class I, Group D hazardous gas locations in paint factories, lacquer plants, oil refineries, chemical houses, or where corrosive and explosive gases are present. Combination switch consists of a magnetic switch, a motor circuit switch, and a thermal overload relay reset by a plunger extending through the top cover. These parts and the connections are located six inches below the surface of the oil in a welded tank. Motor circuit switch is a manual contactor with quick-make and quick-break mechanism interlocked with the tank cover so that the tank cannot be removed unless the motor circuit is open. Available in three sizes for motors up to 50 hp. at 440 volts. General Electric Co., Schenectady, N. Y.

Trumbull Tumbler Switch

Designated as type RB, uses a roller contact construction providing quick-make and quick-break action, is designed for 2-hp., 250 to 600-volt motor or lighting circuit. Available as a switch unit or mounted in a case for surface or flush mounting, and as a float-operated unit. Supplied in three designs: two-pole type, rated at 30 amp, 250 volts and 5 amp., 600 volts; three-pole and four-pole types of the

same rating. A three-way switch rated at 10 amp., 125 volts and 5 amp., 250 volts, is also available. Two-pole and three-way units designed to fit standard wall boxes, are approximately 2⅝x4x3 in. Trumbull Electric Mfg. Co., Plainville, Conn.

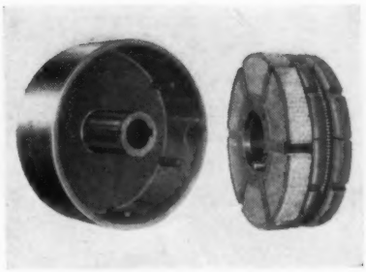
Square D Pushbutton Station

A start-stop pushbutton station, designated as Class 9001, Type B20, with pushbuttons 1-in. in diam. Buttons and stems are molded of bakelite in one piece, are supported by compression springs with additional follow-up spring at the contacts. Double break contacts are silver-to-silver, with

mechanism mounted on a porcelain base, removable as a unit from the inclosure. Also available in dust-tight and water-tight inclosure. Dimensions are 2½-in. wide, 4¼-in. high, 2⅝-in. deep. Square D Co., Industrial Controller Div., 710 S. Third St., Milwaukee, Wis.

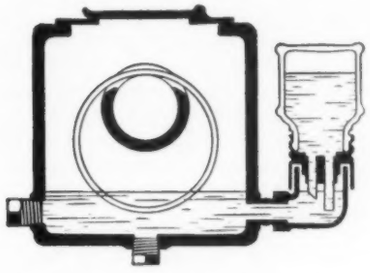
Zobell-Waterhouse Coupling

Designed to disengage a driven machine when subjected to excessive overload. Coupling consists of a starting section and a service section; each section consisting of a ring of segments operated by centrifugal force. Starting section segments rotated by the drive shaft are held in contact with central body section of the coupling by a garter spring designed to give the required starting torque but to release under the centrifugal force developed at a speed under the full load speed. Service section segments rotated by the driven shaft are designed so that centrifugal force at load speed allows this section to carry the full load. Starting section carries the load during the starting period, but disengages as the load speed is reached, and the service section carries the load. When an overload slows down the driven machine the service section disengages and disconnects the drive, which then runs idle. To reset, the driving motor is stopped and restarted. Couplings are designed to operate without oil and are said to function equally well in either direction of rotation. Zobell Electric Motor Corp., Garwood, N. J.



Speedway Constant Level Oiler

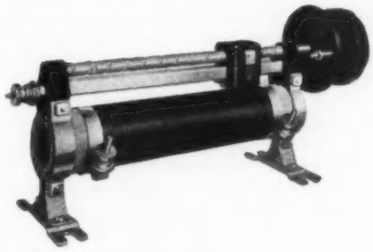
For reservoir bearings with oil-ring, packing, or ball or roller bearing, designed to maintain the oil at a constant level in the bearing. Oil is carried in an inverted cup from which two tubes



extend down to the normal oil level. When the oil level falls below the end of the shorter tube, air enters the tube allowing oil in the cup to flow into the reservoir until the opening to the shorter tube is covered. Oilers are claimed to maintain a constant level without over-oiling, to reduce inspection time, to eliminate oil dripping. Speedway Mfg. Co., 1834 South 52d Ave., Chicago, Ill.

Ward Leonard Tubular Rheostats

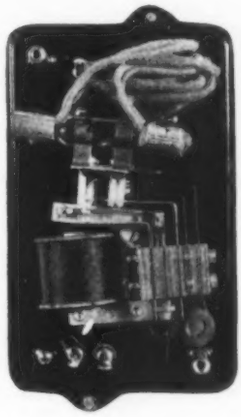
Designed for accurate control of currents up to 25 amp., are arranged



for potentiometer connection, and may be obtained with non-inductive or tapered resistance windings. Single contact point is of silver. Available in three lengths, 8 in., 16 in., 20 in.; cover a wide range of resistance values. Also available with micrometer drive incorporating a clutch allowing single-hand adjustment of the slider. Escapement at the ends of the drive shaft designed to prevent straining the assembly when the slider reaches the end of travel. Ward Leonard Electric Co., Mt. Vernon, N. Y.

Guardian Projector Relay

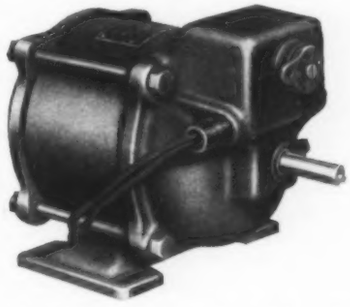
For reversing a projector motor and associated apparatus provides a compact control. Four single-pole, double-



throw circuits, rated at 10 amp. are broken in air, two single-pole, mercury switches are rated at 20 amp. Actuating coil available for either a.c. or d.c. operation for closing currents from 5 milliamperes to 5 amp. Guardian Electric Mfg. Co., 1522 W. Adams St., Chicago, Ill.

Century Explosion-Proof Motor

Designed for automobile filling station gasoline pumps, is available in split-phase, repulsion start single-

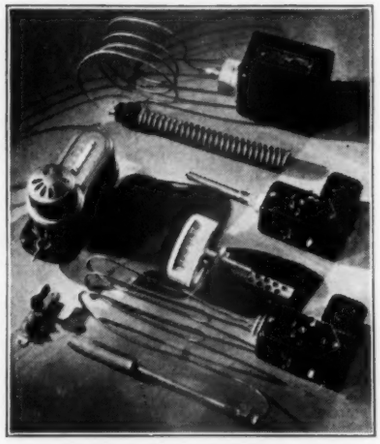


phase, or direct current types. The frame is of rolled steel with cast iron end brackets, has no removable plugs or caps. Switch shaft and motor shaft

bearing housings are flanged and drained to prevent entrance of gasoline. Bearings are phosphor bronze, wool yarn lubricated. Switch, operated from the nozzle hook, completely inclosed in end brackets, is a double-pole circuit breaker incorporating thermal overload protection. Terminals are brought out through a pipe nipple and sealed with a compound said to be unaffected by gasoline. Century Electric Co., St. Louis, Mo.

Line of Temperature Controls

For use in connection with heating applications for indicating and controlling temperatures in tanks, machines, hydraulic press platens, ovens and furnaces, melting pots and other equipment. Thermostats for controlling the temperature of electric



units used for heating rooms, shops and offices. Edwin L. Wiegand Co., 7577 Thomas Blvd., Pittsburgh, Pa.

NEW BOOKS and PUBLICATIONS

Industrial Research Laboratories of the United States

Bulletin No. 91 of The National Research Council. Released August, 1933. Compiled by Clarence J. West and Callie Hull. 223 pages, 6¾x9¾ in. Paper covers. Published by The National Research Council of The National Academy of Sciences, Washington, D. C. Price $2.

1,562 industrial companies maintaining research laboratories are listed in this bulletin. Research laboratories of colleges and universities, and commercial testing laboratories are not included. In each case the product of the company, the type of research engaged in, and the size of the research staff with the name of its director are given. The laboratories are indexed by geographical distribution and by subject. This bulletin should be invaluable to anyone wanting to know where any particular type of research is being conducted, and by whom.

Procedure Handbook of Arc Welding, Design and Practice

434 pages, 5¾x9 in. Heavily illustrated. Flexible binding. Published by the Lincoln Electric Co., Cleveland, Ohio. Price $1.50.

Its compilers have included in this volume practical information for the designer and for the welder and welding department executive. A brief chapter on the various types of welding and the equipment required for each acts as an introduction to the rest of the book which is confined to arc welding. Part II is devoted to the technique of arc welding; Part III to procedures, speeds and costs for welding mild steel; Part IV to the structures and properties of weld metal; Part V to the weldability of various metals; Part VI to designing for arc-welded construction of machinery; Part VII to designing for arc-welded structures; and Part VIII to typical applications. The numerous examples make the book practically useful to anyone having anything to do with welded design or construction.

Manual on Presentation of Data

A.S.T.M. Manual on Presentation of Data, 1933. 45 pages, 6x9 in. Paper covers. Published by the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Price 50 cents.

Prepared by a committee of engineers experienced in statistical work. Discusses the application of statistical methods to problems of condensing information contained in a set of observations and the presentation of the essential information in an organized form.

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Research Bulletins

Engineering Experiment Station, Purdue University, Lafayette, Ind., Bulletin No. 44, "Riding Comfort Analysis" by H. M. Jacklin and G. J. Liddell presents the progress to date of two related investigations, the measurement of vibration in vehicles, and the effect of vibrations on humans. Both investigations were carried on concurrently in the Engineering Experiment Station. The report on the first investigation describes the tests results obtained with an accelerometer used in analyzing the motion of passenger cars. The design and use of the vibrating platform in determining human reactions to vibration is included in the second report. Methods are given for analyzing accelerometer records in terms of human reaction. Price $1.

U. S. Department of Commerce, Bureau of Standards, Washington, D. C. Research Paper No. 551, "Tin-Free Leaded Bearing Bronze," by H. K. Herschman and J. L. Basil, Bureau of Standards, is a reprint from *Bureau of Standards Journal of Research,* Vol. 10, May, 1933. Copper-lead alloys containing 35 to 50 per cent lead were subjected to laboratory and service tests showing that single additions of small amounts of barium, calcium, zirconium or sulphur aided in preventing segregation of the lead. Other tests indicate that this material can be handled commercially in the manufacture of bearings. For sale by Superintendent of Documents, Washington, D. C., price 5 cents.

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Chain Drive — Diamond Chain & Mfg. Co., Indianapolis, Ind. Catalog No. 583, 96 pages, "Diamond Chains and Sprockets," a designer's handbook on chain drives. Includes data on the selection of size and type of chain and sprocket, with catalog information and data on rating, installation, lubrication.

Color — Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Reprint, 8 pages, "Color and Color Matching," characteristics of transmitted and reflected colors, the human eye, photo-electric devices.

Lubricants — The Pure Oil Co., Chicago, Ill. Mechanical Bulletin No. 57, 50 pages, "Lubrication of Bearings," a well-illustrated, practical treatment for the designer. Sections on the mechanism of journal bearing lubrication, types of bearings, bearing metals, products of the company and various types of oiling devices.

Photo-electric Relays—General Electric Co., Schenectady, N. Y. Data book GEA-1654A, 16 pages, "CR7505 Photo-electric Relays," includes a list of applications and information on the principles of operation of the phototube, amplifier tube, relay tube, and the performance of the complete relay. Data also included on accessories and illumination.

Plastics—General Electric Co., River Works, West Lynn, Mass. Data booklet G.E.A.-937C, 36 pages, "Plastic Products Price List," well-illustrated information on the application of hot-molded, cold-molded and laminated parts and gears. Included is a 2-page table on the properties of the hot-molded material, and data on machining. Catalog information includes tolerances, cutting charges and list of available standard products.

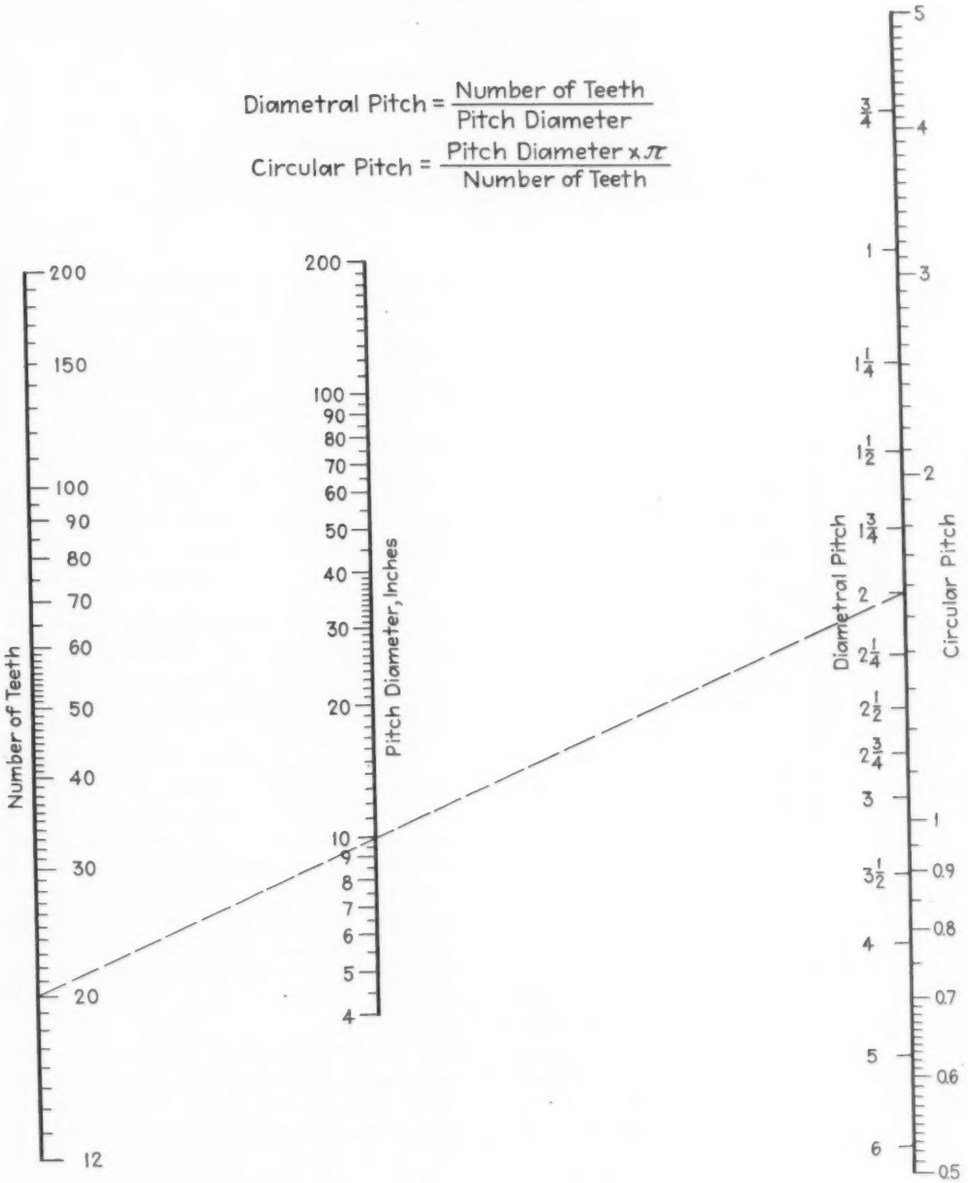
Remote Control Equipment—Hart Manufacturing Company, Hartford, Conn. Bulletin No. 10-A, 32 pages, "Diamond H Remote Control Switches," with description, wiring diagram, typical installations and catalog information on a line of switches and relays.

Relation Between Pitch, Pitch Diameter and Number of Teeth

Contributed by E. Cowan
New York, N. Y.

$$\text{Diametral Pitch} = \frac{\text{Number of Teeth}}{\text{Pitch Diameter}}$$

$$\text{Circular Pitch} = \frac{\text{Pitch Diameter} \times \pi}{\text{Number of Teeth}}$$



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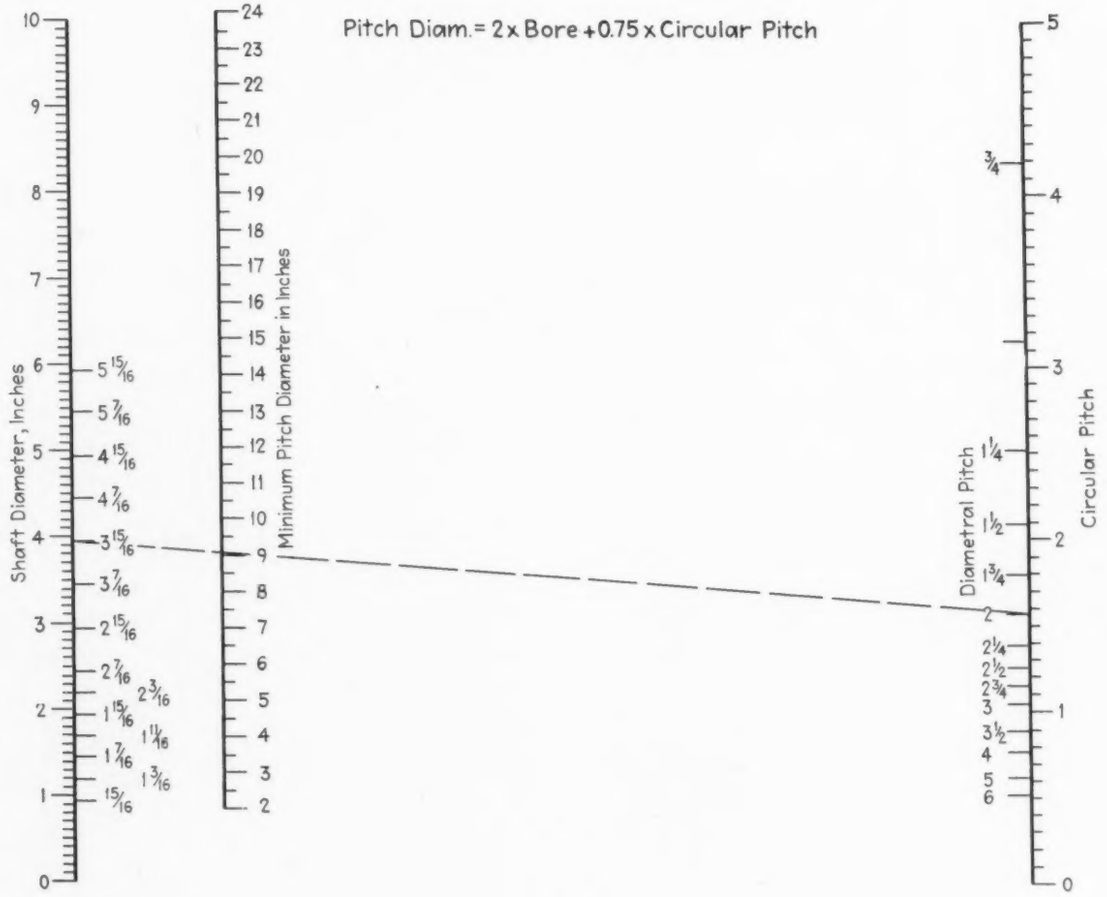
Minimum Pitch Diameter of Spur Gears

Contributed by E. Cowan
New York, N. Y.


Pitch Diam. = 2 x Bore + 0.75 x Circular Pitch
Shaft Diameter, Inches
Minimum Pitch Diameter in Inches
Diametral Pitch
Circular Pitch

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